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Rocky Mountain
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Fort Collins
Colorado 80526

General Technical Report
RM-GTR-273

FIRE EFFECTS ON ARCHAEOLOGICAL RESOURCES, PHASE 1:

THE HENRY FIRE, HOLIDAY MESA, JEMEZ MOUNTAINS, NEW MEXICO

Stephen C. Lentz, Joan K. Gaunt, and Adisa J. Willmer

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The effects of wildfire on cultural resources were evaluated on sites in the Jemez Mountains of New Mexico. Guidelines were developed for protecting cultural resources during prescribed burns and wildfire. Six sites burned during the Henry Fire, and one unburned control site, were investigated. The findings generated by the Phase I research will be used to develop a comprehensive research design for Phase II. The Phase II portion of the study will focus on using experimental data to develop management recommendations for use in prescribed burn situations in accordance with existing state and federal regulations designed to preserve and protect cultural resources.

Keywords: cultural resources, Jemez Mountains, Henry Fire, prescribed burns, fire effects, archaeology

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Joan K. Gaunt *is a professional archaeologist who has worked in the Southwestern United States since 1983. After graduating from the University of Colorado in 1980, she did cultural resource inventories and ruins stabilization projects in Colorado, northeastern Arizona, and southeastern Utah. In 1989, after joining the Museum of New Mexico, Joan performed a number of cultural resource management projects in northern and southwestern New Mexico. In 1993, she began co-directing Phase II of the Jemez Fire Study.*

Adisa J. Willmer *graduated from the University of New Mexico in 1985 and has worked in cultural resource management and for the USDA Forest Service throughout New Mexico. She has also participated in archaeological and ethnoarchaeological projects in France and Mexico. In 1988 she joined the Museum of New Mexico and supervised numerous survey, testing, and data recovery projects for the New Mexico State Highway and Transportation Department and the Mining and Minerals Division of the Department of Energy, Minerals and Natural Resources. She became field supervisor for the Jemez Fire Study in 1992. She is currently a medical student at the University of New Mexico.*

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GLOSSARY

Following is a lexicon of terminology developed for this project by the USDA Forest Service (USFS) and the Office of Archaeological Studies, Museum of New Mexico.

BLA: acronym for burned log area. A log or large branch burning on a site (see Residence Time, below). All burned sites (except AR 1930, where it was not determined) had BLAs.

Fire Intensity: also known as Fire Line Intensity. It is the heat release rate per unit length of fire line at the fire front, and it is used to calculate flame length (BTU/ft/second). For the purposes of archaeological research, severity of burning is expressed in low, moderate, and heavy intensities.

Fuel Load: (for archaeological sites) the amount of combustible fuel types within the site parameters, i.e., slash, dead and down, duff, woody debris.

Fuel Model: a term used by the USFS fire organization to describe the immediate flora within an ecozone. Phases I and II of the project will consider six of the twelve fuel models used by the USFS: Model 2—open pine with herbaceous fuel; Model 4—chaparral; Model 5—brush fields with litter; Model 9—closed timber with loosely compacted needles, litter, and some branchwood; Model 10—mixed conifer with heavy litter, branchwood, and logs; and Model 11—light loading of activity fuels including light partial cuts or thinning operations. Models 12 and 13 are heavier loadings of activity fuels.

Prescription: a written statement used by the USFS defining objectives to be attained as well as temperature, humidity, wind direction, wind speed, fuel moisture content, and soil moisture under which a prescribed fire will be allowed to burn, generally expressed as acceptable ranges of the various indexes and the limit of the geographic area to be covered.

Residence Time: the amount of time (duration) spent (by fire) at a certain location. For example, the residence time at a site is increased by the presence of a burning log. If a fire passes over an area quickly, there is decreased residence time.

Threshold: the temperature or fire line intensity at which significant damage to cultural resources begins to occur.

FIRE EFFECTS ON ARCHAEOLOGICAL RESOURCES, PHASE 1: THE HENRY FIRE, HOLIDAY MESA, JEMEZ MOUNTAINS, NEW MEXICO

INTRODUCTION

Stephen C. Lentz, Office of Archaeological Studies

This report presents the Phase I results of a joint project between the Office of Archaeological Studies (OAS) of the Museum of New Mexico and the USDA Forest Service (USFS). The objectives of this study were to

- determine whether cultural resources were negatively affected by prescribed burns or wildfire,
- determine the degree to which data loss occurs, and
- make management recommendations in compliance with existing state and federal regulations for protecting and preserving cultural resources.

Prompting this study was the Henry Fire of 1991, which occurred on National Forest lands on Holiday Mesa in the Jemez Mountains of New Mexico. Before the wildfire was contained, 807 acres of forest land had been burned. There were numerous prehistoric sites in the burn area, many of which were burned to varying degrees. Six sites from the Henry Fire burn area were studied along with a seventh unburned site.

The project is intended as a two-part study. The Phase I study gathered information on the effects of the Henry Fire on cultural resources in the Jemez Mountains. The findings and hypotheses generated by Phase I will contribute to a detailed research design for Phase II, which is presented at the conclusion of this document.

Project field work was conducted between May 18 and May 22, 1992, and between June 2 and June 4, 1992. The OAS archaeologists were Stephen C. Lentz, Joan K. Gaunt, and Adisa J. Willmer. Sam Sweezy assisted during field work. During the Phase I portion of the project, limited surface collections and test pit excavations were conducted at seven sites on lands administered by the U.S. Forest Service, Santa Fe National Forest (fig. 1). Specifically, the project area was located on Holiday Mesa, 12.9 km (8 mi) northwest of La Cueva, New Mexico. Three classes of artifacts were recovered: lithic artifacts, ceramic artifacts, and ground stone. No whole ceramic vessels were present during testing, nor were any faunal or botanical remains recovered. No features were exposed. The results and interpretation of the artifact analysis and the management recommendations are included in this report. The sites that were investigated are (USFS site identification numbers) AR-03-10-03-1905, AR-03-10-03-1930, AR-03-10-03-1961, AR-03-10-03-2513, AR-03-10-03-1931, AR-03-10-03-2516, and AR-03-10-03-1886 (unburned control site). The legal descriptions and locations of these sites are not included in this report, but may be obtained through USFS.

The funding source for the study was the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. The Santa Fe National Forest provided both archaeological and fire behavior expertise at several points during the study. The Bureau of Land Management in Santa Fe and the National Park Service in Bandelier National Monument contributed to the project through participation and discussion sessions.

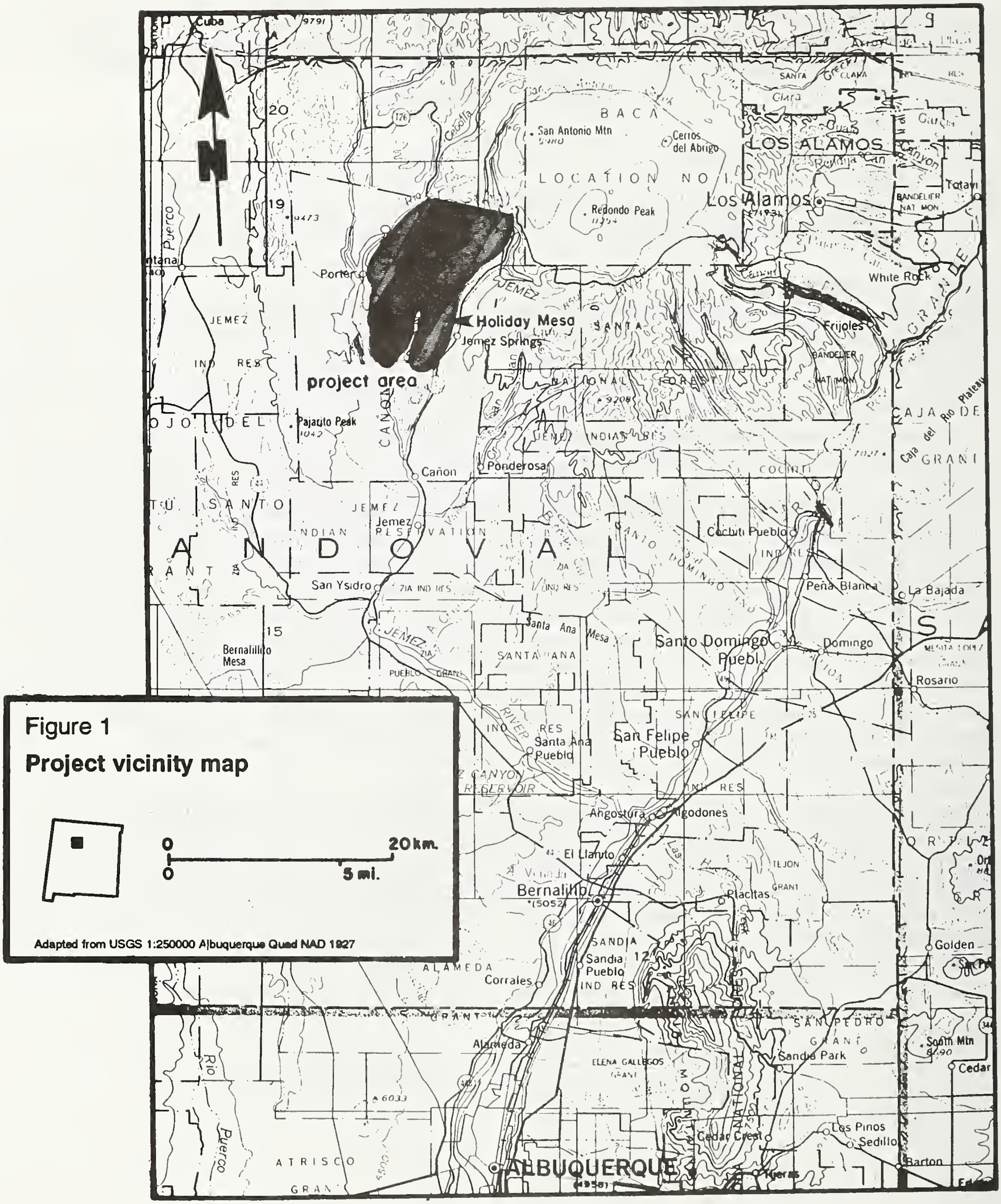

Figure 1—Project vicinity map.

RESEARCH ORIENTATION

Tom Cartledge, USDA Forest Service Archaeologist, Santa Fe

Each year in the U.S. Forest Service's Southwestern Region, anywhere from 20,000 to 50,000 acres, and occasionally more than 100,000 acres, are impacted by wildfire. Efforts are made to consider the protection of cultural resources in suppression activities, and archaeologists are usually involved in monitoring the use of heavy equipment in suppression, mop up, and rehabilitation activities. A variety of cultural resources are damaged by wildfire. Most often noted is the loss of historic buildings. The Haught Cabin, a structure listed on the *National Register of Historic Places*, was destroyed by the Dude Fire on the Tonto National Forest in June 1990; the historic Grudgings Cabin was lost in the Grudgings Fire on the Gila National Forest in May 1991; and half of the remaining impressive log structures at the Holiday Logging Camp, scheduled for nomination to the *National Register of Historic Places* this year, were destroyed by the Henry Fire itself. Less apparent, and more difficult to assess, is the damage to archaeological remains such as pueblo ruins, artifact scatters, and other prehistoric and historic cultural resources. The area burned by the Henry Fire contains 52 prehistoric sites. An inventory of the burn area indicated varying degrees of burning and damage. Currently, however, there are no systematic, objective techniques for assessing and describing the severity of damage to artifacts, masonry walls, and other features, or for determining the nature of the fire at a particular site.

In addition to wildfire, the USFS conducts prescribed burns in the Southwest on between 70,000 and 100,000 acres each year for fuels management, brush disposal, and range and wildlife habitat improvement. For years it has been assumed that prescribed fires are relatively "cool" burns, with little affect on cultural resources, other than on wood and organic materials. The actual effects of prescribed fire on various types of cultural materials, however, are inadequately investigated and poorly understood.

It is still unknown, for example, the temperatures at which stone artifacts start to spall or crack, or how fire affects obsidian artifacts compared to chert or basalt; how exposure to fire affects the ability to date artifacts using obsidian hydration and other techniques; or how fire effects may alter the data potential of diagnostic artifacts. Little is known about the effects of fire on surface ceramics, or about the role temperature, fire line intensity, and other variables play in the management of cultural resources. Because of the absence of good information, the impacts of fire on cultural resources may be seriously underestimated or overestimated. Irreplaceable cultural resources may or may not be seriously damaged in prescribed fire programs.

In 1988 a symposium sponsored by the Rocky Mountain Forest and Range Experiment Station and the Southwestern Region of the Forest Service was held at Grand Canyon to explore the possibility of developing a Forest Service cultural resources research program in the Southwest (Tainter and Hamre 1988). Numerous archaeologists from various federal agencies and various academic institutions participated. One of the many research topics identified at the symposium was the need for an experimental approach to studying the effects of prescribed burning and wildfire on archaeological sites and materials. It was widely recognized that the best way to approach such a study would be experimentally, i.e., gather various baseline data about sites and materials prior to burning, then burn across sites and materials with fire of varying intensities, and then collect additional data to compare back to the baseline data in order to accurately monitor changes. Then a wildfire (the Henry Fire) occurred on Holiday Mesa on the Santa Fe National Forest in an area that had already been completely surveyed for cultural resource sites. A decision was made to take immediate advantage of this opportunity to assess the effects of the Henry Fire on the already recorded sites as a preliminary step that might help achieve greater refinement of the hypotheses we were intending to test under experimental circumstances. That decision resulted in the current volume, which we have labeled "Phase I." The ultimate goal has been, and still is, to conduct controlled experiments of the effects of fire on archaeological resources. Planning and funding for such experiments are well underway and will result in a subsequent volume, or Phase II of this study.

BEHAVIOR OF THE HENRY FIRE IN THE JEMEZ MOUNTAINS

Les Buchanan, Fire and Fuels Management, Santa Fe National Forest
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Fire Summary

The Henry Fire occurred on Holiday Mesa in the Jemez Ranger District of the Santa Fe National Forest (fig. 2). The area is located at roughly 8,000 ft in elevation in second growth ponderosa pine. The Henry Fire was reported by Cerro Pelado Lookout at 1430 hours, Thursday, June 27, 1991. Initial attack was made by Jemez District personnel. Due to dense ponderosa pine sapling stands and dry fuels, the fire grew quickly, and extreme fire behavior was common. The Henry Fire was one of the more intense fires in northern New Mexico since the late 1970s. The Henry Fire was contained at 807 acres on June 29, and controlled at 1800 hours on June 30.

Past Fire History

The past history of fire in the Jemez Mountains is based upon studies done by Thomas Swetnam (1991) of the Laboratory of Tree-Ring Research, University of Arizona. In his study, Swetnam describes the fire history based on tree-ring research as follows: The "natural" fire regime, characterized by frequent surface fires, ended around 1900. Fire-scar dates were synchronous among most trees indicating that the recorded fires were generally widespread throughout the study area. Approximately 70 percent of the fire scars occurred within the early wood portion of the annual rings, which probably corresponds to the period from May to August. Approximately 30 percent of all observed scars occurred during the first two-thirds of the early wood part of the ring, indicating early season fires from May to June.

The fire frequency within these general areas was every 5 to 7 years. This information is presented in table 1. Although these findings were derived outside Holiday Mesa, the data from Swetnam's study areas appear to be pertinent to the Henry Fire area. For example, Monument Canyon and Holiday Mesa have similar fuel types, longitude, and elevation; both are located on mesas only 4 miles apart.

Beginning in 1900, the fire frequency abruptly stopped (fig. 3, Swetnam 1991). This was due in part to extensive heavy grazing and the aggressive fire suppression tactics of the USFS. As a result of heavy grazing (decrease of the grasses that carried the fire) and fire suppression, fuel loadings began to increase throughout the forest. Natural fires were no longer permitted to play the role of reducing natural fuel buildup. Natural fuel buildup is continually created by needle and leaf cast, and natural breakage and blow down caused by winds, or snow and ice. Pre-1900 fires would reduce this loading every 5 to 7 years and the natural fuel loading process would begin anew.

With the elimination of fire, unnatural fuel loadings began to occur. Unnatural fuel loadings are created by continual accumulation of natural fuels in the absence of fire. The tons per acre of fuel continue to increase year after year. With heavy accumulations of fuel on the forest floor, fires cannot be easily controlled. As a result, the fire intensities after 1900 were much higher than the natural fires of pre-1900. The Henry Fire is a typical example of what may occur in a modern-day wildfire because of unnatural fuel loadings.

Fire Behavior

The following study of the fire behavior of the Henry Fire was completed to assist in identifying the intensity of fire that occurred on archaeological sites

Table 1—Fire interval statistics from 1600–1899.

Study Area	Mean (years)	Standard Deviation (years)	Maximum (years)	Minimum (years)
Capulin	7.1	5.5	21	1
Monument Canyon	5.8	2.7	12	1
Gallina Mesa	5.1	3.4	16	1

Source: Swetnam 1991

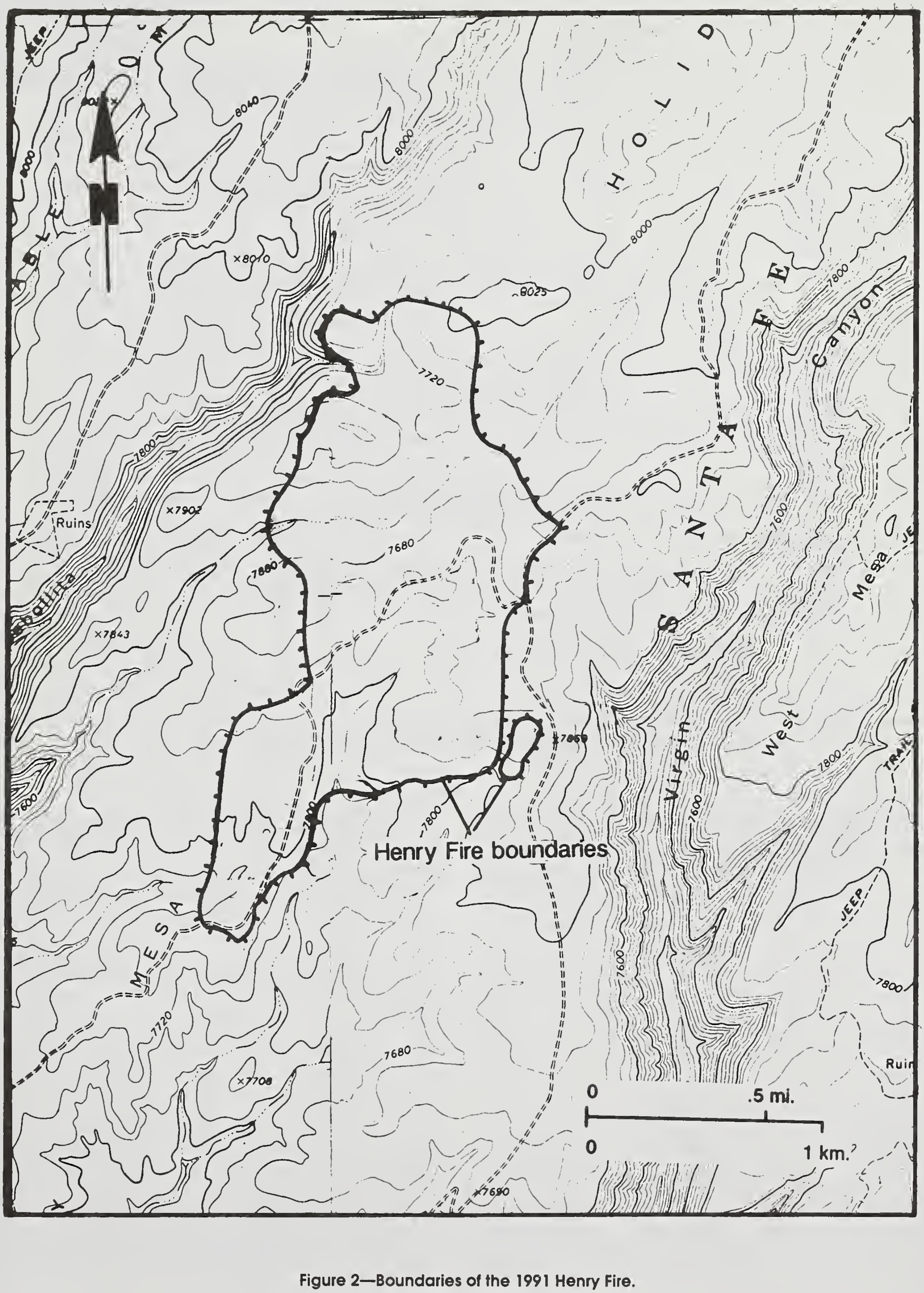

Figure 2—Boundaries of the 1991 Henry Fire.

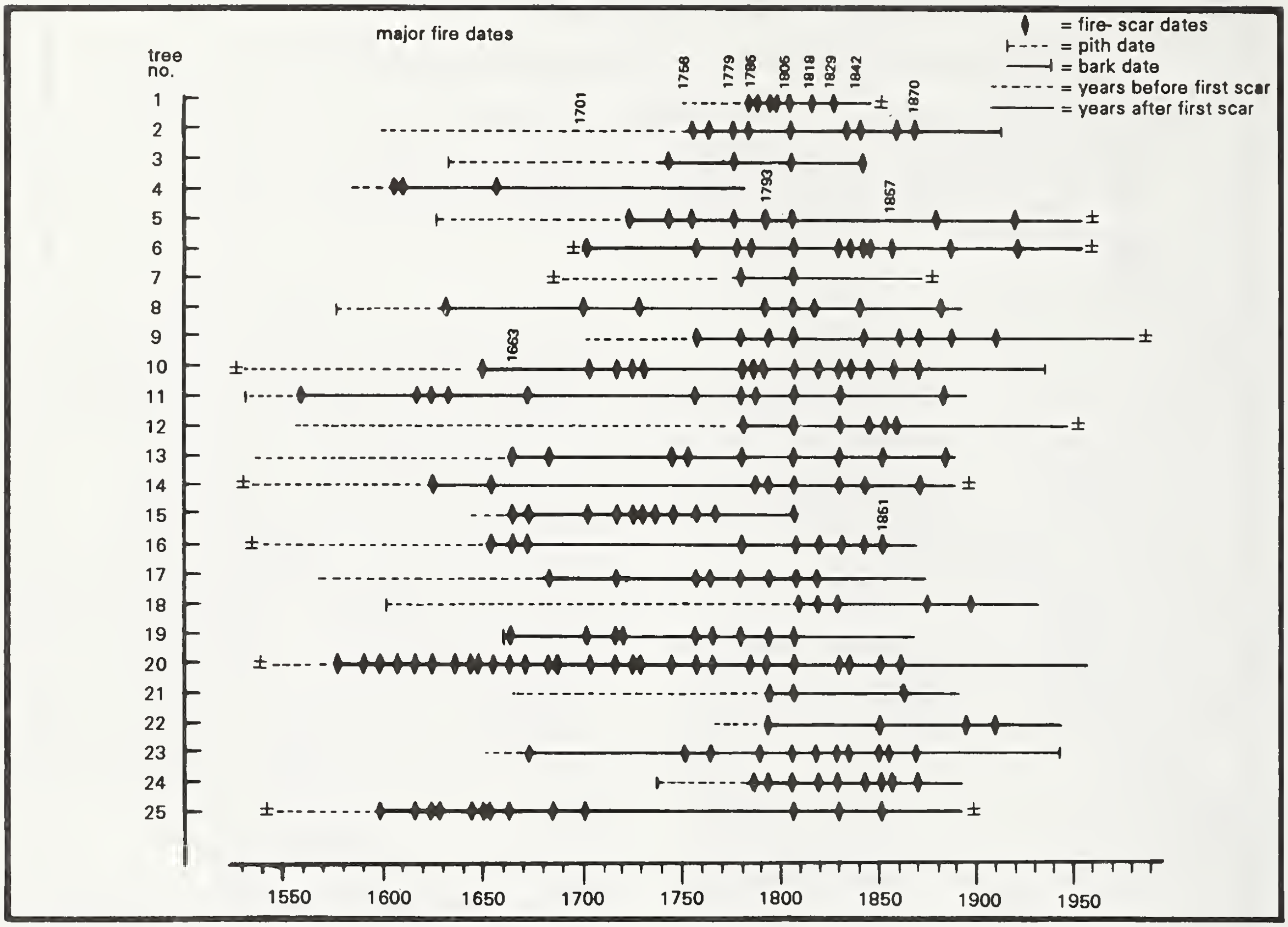

Figure 3—Fire dates in the study area (after Swetnam 1991).

in the burned area. Estimates of fire-line intensity (based on Rothermel 1991, see definition in Glossary) and estimates of flame lengths (maximum height of flames measured from the ground) were made during the Henry Fire. These estimates were again confirmed during the studies conducted on August 21–23, 1991, in conjunction with a cultural resource resurvey. Post-fire indicators for fire-line intensity (FLI) and flame lengths (FL) on different areas of the burn included total crown consumption, scorch heights, partial or total consumption of duff and litter, partial or total exposure of mineral soils, and partial or total consumption of small (sapling/pole) conifers.

Documents utilized for determining fire behavior include a paper that provides ground charring descriptions (Ryan and Noste 1983) used by the fire behavior team, such as light ground char, moderate ground char, or deep ground char (table 2). These categories classify ground char according to visual characteristics of the depth of ground char and the extent to which fuels were burned, particularly on the soil surface.

Criteria developed by Rothermel (1991) were utilized in obtaining fire-line intensity equivalents in flame lengths. All fire behavior model outputs are expressed in rates of spread, fire line intensity, and flame lengths, which are measures that cannot be converted to temperature. It is possible to estimate flame length from direct observation during the burn, or from observed scorch height after the burn. General flame lengths for the Henry Fire were observed by Les Buchanan and Phil Neff during the active phase of the wildfire. Flame lengths at specific archaeological sites, however, were not observed. Further explanation of FLI and FL is given in Byram's definition of FLI (Byram 1959). Byram states that FLI is the heat release rate per unit length of fireline at the fire front. Sometimes this is called fire intensity.

Table 2—Ground char categories.

Category	Characteristics
Light	Leaf litter is charred or consumed. Upper duff may be charred, but the duff layer is not altered over the entire depth. The surface generally appears black immediately after the fire. Woody debris is partially burned. Some small twigs and much of the branch wood remain. Logs are scorched or blackened but not charred. Crumbled, rotten wood is scorched to partially burned. Light ground char commonly makes up 0-100 percent of burned areas with natural fuels and 45-75 percent of slash areas.
Moderate	Litter is consumed. Duff is deeply charred or consumed but the underlying mineral soil is not visibly altered. Light colored ash prevails immediately after the fire. Woody debris is largely consumed. Some branch wood is present, but no foliage or twigs remain. Logs are deeply charred. Moderate ground char commonly occurs on 0-100 percent of natural burned areas and 10-75 percent of slash areas.
Deep	Litter and duff are completely consumed, and the top layer of mineral soil is visibly altered, often reddish. Structure of the surface soil may be altered. Below the colored zone, 1/2-inch or more of the mineral soil is blackened from organic material that has been charred or deposited by heat conducted downward. Twigs and small branches are completely consumed. Few large branches may remain, but those are deeply charred. Sound logs are deeply charred, and rotten logs are completely consumed. Deep ground char occurs in scattered patches under slash concentrations or where logs or stumps produced prolonged, intense heat. Deep ground char generally covers less that 10 percent of natural and slash areas. In extreme cases, clinkers or fused soil may be present. These are generally restricted to areas where slash was piled.

Source: Ryan and Noste 1983

Fire intensity, measured in BTU/ft/sec, is a good indicator of the severity of the fire front and can be used to calculate flame length. Thus, the FLI measures can be used to determine the intensity of fire that may cause damage on archaeological sites.

The OAS, Museum of New Mexico, has test excavated and studied damage on six sites burned by the Henry Fire (table 3). These sites include areas determined to be lightly burned, moderately burned, and heavily burned. One control site, AR-1886, was not burned and was used for comparison purposes.

An additional 39 sites were inventoried during the fire behavior survey (table 4). For the sites with flame lengths 7 ft or less (FLI of 400 BTU/ft/sec or less), no observable damage to archaeological sites was indicated.

Table 3—Behavior of the Henry Fire at Phase I study sites.

Site number	Flame length (ft)	Fire line intensity (BTU/ft/sec)	Ground char class	Burn intensity
AR-1961	1.0	5	Light	Light
AR-2516	1.5	15	Light	Light
AR-1905	75.0	7,260	Moderate	Moderate
AR-2513	10.0	850	Moderate	Moderate
AR-1930	75.0	7,260	Deep	Heavy
AR-1931	75.0	7,260	Deep	Heavy

Note: Site AR-1905 (moderate), and sites AR-1930 and AR-1931 (deep char) all generated flame lengths of 70+ ft. The difference in charring was a direct result of the live crown height above the ground before the burn. These three sites burned with a crown fire. Site AR-1905 (moderate char) had a live crown base of 12 ft. Sites AR-1930 and AR-1931 (deep char) had a live crown base of 6 ft. All three sites were located in heavy regeneration (doghair thicket) areas of ponderosa pine.

Table 4—Fire behavior at other sites within the Henry Fire.

Site number	Flame length (ft)	Estimated fire line intensity (BTU/ft/sec)	Ground char	Observed damage
AR-1892	1.0	5	Unburned	None
AR-1884A	2.5	41	Light	Ceramics discolored
AR-1884B	2.0	25	Light	None
AR-1885A	75.0	7,260	Moderate	50 pct. spalling, alum. tag melted, obsidian unaltered
AR-1885B	7.5	450	Light	Ceramics discolored, not spalled
AR-1901	75.0	7,260	Moderate	Sooted, discolored sherds; 50 pct. spalling of tuff; obsidian not affected
AR-1904	7.0	400	Light	None
AR-1906	75.0	7,260	Moderate	Sherds sooted, discolored, no spalling; alum. tag melted
AR-1907	75.0	7,260	Moderate	Sherds sooted, discolored, no spalling; alum. tag melted
AR-1908	75.0	7,260	Moderate	Sherds sooted, discolored, no spalling; alum. tag melted
AR-1909	50.0	3,950	Moderate	Sooted ceramics; spalled tuff; alum. tag melted
AR-1912	2.0	25	Light	None
AR-1913	75.0	7,260	Deep	Aluminum tag melted; ceramics sooted, spalled, discolored
AR-1914	50.0	3,950	50 pct. deep	Spalling of tuff; ceramics discolored, not spalled
AR-1915	30.0	1,840	Moderate	50 pct. of ceramics sooted; tag melted
AR-1917	75.0	7,260	Moderate	Aluminum tag melted; ceramics sooted, discolored; tuff spalled
AR-1918	75.0	7,260	Deep	Aluminum tag melted
AR-1919	75.0	7,260	Deep	Aluminum tag melted
AR-1925	5.0	200	Light	None
AR-1928	1.0	5	Light	None
AR-1929	4.0	100	Moderate	None
AR-1932	75.0	7,260	Deep	Same as 1931
AR-1935	2.0	25	Light	None
AR-1936	6.0	200	Light	None
AR-1941	7.0	400	Moderate	Rubble spalled, ceramics sooted
AR-2486	5.0	200	Moderate	None
AR-2488	2.0	25	Light	None
AR-2494	8.0	500	Moderate	None
AR-2497	3.0	60	Light	None
AR-2504	3.0	60	Light	None
AR-2515	15.0	2050	Moderate	Rubble spalling, rock discolored
AR-2517	1.0	5	Light	None
AR-2518	1.5	15	Light	None
AR-2545	.5	3	Light	None
AR-2623	2.0	25	Light	None
AR-2629	75.0	7,260	Moderate	None
AR-2630	50.0	3,950	Moderate	Some spalling, no soot on ceramics
AR-2631	20.0	1,000	60 pct. light 40 pct. moderate	Discolored, sooted ceramics; spalling of tuff
AR-2633	50.0	3,950	Moderate	Ceramics sooted, discolored; spalled tuff

Note: Due to logistical and weather reasons, not all sites were subjected to post-fire data gathering.

PREVIOUS FIRE EFFECT STUDIES

Tom Cartledge, USDA Forest Service Archaeologist, Santa Fe

Information on the effects of fire on cultural resources is limited to scattered reports on studies conducted in the aftermath of wildfires and a handful of largely unpublished experiments using prescribed burns. These studies have not employed control data to compare with the fire data, therefore it has been difficult to adequately discern the severity of the fire damage.

The first systematic fire study was the La Mesa Fire study conducted in 1977 by the National Park Service following a fire in Bandelier National Monument, New Mexico (Traylor et al. 1990). For years the draft of this report has been used as the most detailed and reliable source of data on fire effects. It includes systematic field documentation, test excavations, and laboratory analysis, and produced preliminary information on the effects of fire on pottery and stone artifacts. More recently, fire studies from the California grass fires have produced a considerable amount of data. As part of the Long Mesa Fire study following a fire in Mesa Verde National Park in 1989 (Eininger 1990), a complete annotated bibliography was compiled of all fire studies to date (Duncan 1990). This document should be consulted for a thorough list of fire studies completed through 1989. A number of articles have been published on the effects of fire on soil that are useful in predicting changes in soil properties (DeBano 1969, 1988, 1989). Recent fire effects studies, including the Long Mesa Fire study (Eininger 1990) and the Yellowstone Fire study (Connor et al. 1989; Connor and Cannon 1990), have been largely descriptive. Because varying approaches and techniques have been used in these and a number of other studies, the overall findings have been neither consistent nor comparable. Additional information and research on the role of fire in the National Forests can be obtained from Pyne (1981, 1992).

PREVIOUS RESEARCH IN THE HOLIDAY MESA AREA

Tom Cartledge, USDA Forest Service Archaeologist, Santa Fe

This overview of previous research in the Holiday Mesa area draws heavily from previous work by Whatley (1988). Archaeological investigations have been conducted in the Holiday Mesa area for almost 100 years. A number of larger pueblos were located in the Jemez Ranger District by W. H. Holmes in 1889 while accompanying a field party of the U.S. Geological Survey. He drew basic plan view maps and described site locations. His 1905 article was later published by Hewett in 1906 as "Antiquities of the Jemez Plateau." Included in his survey were the two large Pueblo IV pueblos on Holiday Mesa, Kwastiyukwa (LA 482, FS 11[1]) and Tovakwa (LA 483, FS 7). By 1914, a series of test excavations were carried out at Kwastiyukwa by Wesley Bradfield and others, including the Royal Ontario Museum of Archaeology (Reiter 1938 in Elliott 1982:23).

Since these earlier days of archaeological investigations, the vast majority of cultural resource research conducted on Holiday Mesa has been under the direction of the USFS. A cultural resource survey was conducted for 1 mile of proposed fenceline extending from Virgin Canyon on the east, up across Holiday Mesa to Cebollita Mesa. No cultural resources were found (Wirtz 1977). Two cultural resource surveys were conducted for the Ridge and Alamo salvage timber sales located on Holiday Mesa (Odegaard 1977). No surface ruins were found in the Alamo Salvage Sale area, yet a map showed two prehistoric fieldhouses in the sale area that had been identified by a previous survey. Seven sites were located within the Ridge Salvage Sale. In 1981, two proposed pipeline routes were surveyed, yet no cultural resources were located (Lucas 1981a, 1981b).

A survey was conducted in 1981 on the west side of Holiday Mesa within the area burned in the 1976 Porter Fire (Elliott 1981). Elliott relocated several sites, and recorded 3 additional prehistoric sites. Another survey conducted in 1981 was located within the area burned during the 1971 Cebollita Fire (Mills and Eck 1981). Seventeen sites dating to the Pueblo IV period were recorded; 16 of these were fieldhouses. A small survey was conducted on Stable Mesa following a major fire, but no cultural resources were found (Lucas 1983). Two surveys were completed in 1983 and 1984 for the Lake Fork Pipeline on Holiday Mesa locating 2 fieldhouse structures (Stephenson 1983, 1984). Two surveys of proposed road construction were conducted in 1984, locating 8 cultural sites and reinspecting 16 previously recorded sites (Elliott 1984, Gauthier 1984). A cultural resource survey was conducted on Holiday Mesa along Forest Service Road 608 in 1985 locating 5 fieldhouse sites (Whatley 1985).

A cultural resource inventory of 2,326 acres on Holiday Mesa was performed in 1987. One small Pueblo IV pueblo, 92 Pueblo IV fieldhouse sites, 3 Pueblo IV rock shelter sites, 7 Pueblo IV artifact scatters, 2 pre-Puebloan artifact scatters, 3 historic corrals, and 394 isolated artifact occurrences were recorded (Whatley 1988).

After the 1991 Henry Fire, the decision was made to utilize the area for a study of fire effects on cultural resources, it was determined that the burned area would need to be resurveyed. The purposes of the resurvey were to (1) re-mark sites from which paint markings and aluminum tags had been burned; (2) search for sites that might have been missed in previous surveys; and (3) record fire intensity and extent of burning at each archaeological site within the burn.

The project area is located in Sandoval County, New Mexico, on Holiday Mesa to the west of the Jemez River in Sections 16, 17, and 20 of the Jemez Springs and San Miguel Mountain 7.5' USGS Quadrangles, T 18N, R 2E (NMPM) (see fig. 1). The lands involved in the Henry Fire are between an elevation of 7,000 ft (2,133.6 m) and almost 8,000 ft (2,438.4 m). Vegetation consisted of an overstory of ponderosa pine with an understory of grasses and forbs. Dense stands of doghair thickets of ponderosa pine resulting from logging in the 1920s, 1930s, and 1940s were prevalent on portions of the burned lands. Currently, grass is coming in through the burn. Aside from springs on the mesa top, major water sources are located in Virgin Canyon and Cañon Cebollita to the east and west of Holiday Mesa.

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[1] Archaeological sites are designated by numbers assigned by the Laboratory of Anthropology (LA numbers) or by numbers assigned by the USFS (FS numbers). In discussions of individual sites or artifacts, the designation F.S. refers to Field Specimen and is a provenience designation.

Resurvey was conducted from August 21 to 23, 1991, by a team of archaeologists under the direction of Carol Raish, Jemez District Archaeologist, Tom Cartledge, Santa Fe Forest Service Archaeologist, and William Whatley, Director of Archaeological Research Exploration (ARE). Archaeologists participating in the project included Tom Cartledge, Jeremy Kulisheck, Steve Lang, Judy Propper, Carol Raish, Marian Revitte, Julie Songer, Janet Weeth, and Bill Wyatt from the Forest Service, and William Whatley of ARE. Two student volunteers with ARE, Joe Foster and Julie La Plante, also participated in the survey.

Forest Service fire personnel Les Buchanan, Phil Neff, and Ron Moody accompanied the archaeological crews but did not participate in the actual survey procedures. Fire personnel who accompanied the crews recorded various observations regarding fire intensities at all previously and newly recorded sites within the burned area. This was a preliminary step toward developing fire characteristic categories to be used in assessing variability in fire effects.

The resurvey resulted in locating 45 previously recorded sites within or at the edge of the Henry Fire area. In addition, 9 previously unrecorded sites were located. These sites were inventoried and added to the list of sites within the burned area.

For the purpose of the fire effects study, sites within the burned area were classified as lightly burned, moderately burned, or heavily burned. Two sites were selected from each of these categories for additional study through field data collection. A seventh site, just outside of the burn area, was used as a control site. The results of the data collection and analyses are discussed below.

PHYSICAL ENVIRONMENT

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Environmental factors play an important role in understanding fire behavior and cultural resources, therefore, we present an overview of the physical environment of the study area. Holiday Mesa is a narrow, elongated spur of land located on the southwestern slope of the Jemez Mountains in north-central New Mexico (fig. 1). It is one of four prominent, interconnected mesas that project southwest from the rim of the Valle Grande caldera. Holiday Mesa is geographically delineated by Cebollita Canyon on the west, Virgin Canyon on the east, and Guadalupe Canyon on the south. The northeast-southwest trending mesas include Virgin Mesa to the east and Stable and Schoolhouse mesas to the west (Whatley 1988:5). The elevation of Holiday Mesa ranges from 2,287 m (7,500 ft) at the mesa's southern rim to 2,439 m (8,000 ft) at the northern end.

Geology

Holiday Mesa is composed of volcanic tuff, attributable to the mid-Pleistocene Tshirege Member and the early Pleistocene Otowi Member of the Bandelier Tuff Formation (Smith et al. 1970). This formation consists of unconsolidated pumice deposits, pumicerous rhyolitic-brecchiated tuff, and welded rhyolitic tuff. The Bandelier Tuff Formation may be in excess of 1,000 ft thick in areas. The formation was created during a series of ancestral volcanic eruptions that formed both the Valle Grande caldera and the nearby Toledo caldera between 1.1 and 1.4 million years ago. Underlying the Bandelier Tuff Formation is the mid-Pliocene Paliza Canyon Formation, which is composed of andesitic rocks. Below this is the Cutler Formation, composed of undivided sandstone, and the Sandia Formation, which is composed of Madera Sandstone (Smith et al. 1970).

Hydrology

Seasonal water sources are located in the canyon bottoms, and the Río de Las Vacas, located south of Holiday Mesa, constitutes a major perennial water source. In addition, numerous springs exist in the area, particularly in Cebollita Canyon, which borders the west side of Holiday Mesa (Whatley 1988:5).

Soils

Soils on Holiday Mesa consist of shallow to moderately deep horizons with dark gray, noncalcareous silt loam surface layers and pale brown to yellowish brown gravelly sandy loam and subsoils. These soils are underlain by volcanic rocks, mainly rhyolite, andesite, or pumice at depths ranging from 25.4 to 76.2 cm (10 to 30 inches). The other group of soils are moderately deep to deep, have a very dark gray, noncalcareous silt loam surface soil over subsurface layers of light gray, very fine sandy loam. The depth to rhyolite, andesite, or pumice is 60.96 to 101.6 cm (24 to 40 inches) or more. Rockland, a miscellaneous land type, is common in rough and steep mountain sides. It consists of a complex of very shallow soils and outcrops of various types of volcanic rocks including rhyolite, andesite, tuff, and pumice. Deep alluvial soils also occur to a limited extent in this association. These soils usually occur on the narrow floodplain contiguous to a major drainage. Although quite variable, the soils are generally deep, moderately permeable, and range in texture from medium to moderately fine (Maker et al. 1971).

Vegetation

Vegetation on Holiday Mesa consists of mixed conifer overstory in combination with a mixed shrub/short grass understory. It is primarily a ponderosa pine environment with occasional open mountain meadows. The dominant vegetation includes ponderosa pine, piñon pine, aspen, Gambel's oak, and New Mexico locust. Other observed species include mountain mahogany, grama grass, mountain muhly, wild onion, little bluestem, wild strawberry, oat grass, sheep fescue, nine bark rock spiraea, flax, Canada wild rye, and cliff rose.

Temperature

The project area is subject to large diurnal temperature fluctuations that occur as the result of wind patterns and topography. The average daily minimum temperature in January is 12° F (–11.1° C), while the average maximum temperature is 44° F (6.7° C). The mean minimum temperature in July is 51.8° F (11° C), and the mean maximum temperature is 89.6° F (32° C) (Stahler and Stahler 1973:60). However, because temperature drops at an average of 3.5° F (1.94° C) per 1,000 ft (304.8 m), the importance of elevation must be considered in local temperature averages.

Rainfall

Rainfall is usually higher in the mountains due to the orographic phenomenon (Bailey 1913). The annual rainfall for the area of the Jemez Mountains (monitored for Jemez Springs) is 46.48 cm (18.3 inches) (Tuan et al. 1973:18). The average winter precipitation is 6.32 cm (2.49 inches), spring precipitation is 9.2 cm (3.62 inches), summer precipitation is 16.53 cm (6.51 inches), and fall precipitation is 14.42 cm (5.68 inches) (Tuan et al. 1973:30–33). Much of the summer precipitation may be in the form of "monsoon" pattern rains that may deposit up to several inches during a single episode.

Fauna

Common and observed species include brown and golden bear, white-tailed deer, elk, chipmunk, deer mouse, coyote, mountain lion, bobcat, cottontail rabbit, white-tailed prairie dog, gray squirrel, red-tailed hawk, goshawk, Mexican spotted owl, the common flicker, Stellar's jay, American robin, dark-eyed junco, Gapper's red-backed vole, and mountain blue-bird. The reader is referred to the ecological overview of the Jemez Mountain range (including fire effects) provided by Craig Allen's (1989) dissertation.

CULTURAL HISTORICAL BACKGROUND

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To better understand the context in which this study was performed, a cultural historical background is presented. There are several cultural overviews of north-central New Mexico already in existence (Cordell 1979, Stuart and Gauthier 1981, 1984). The following summary is concerned primarily with the relevance of regional culture histories to the project area, and is adapted from Lent and Trierweiler (1990).

Paleoindian Period

Archaeological evidence suggests that the Jemez Mountains have sustained at least intermittent occupation for the past 12,000 years. Material remains from the earliest hunters and gatherers, the Paleoindians, are at present limited to surface finds. It is probable, however, that the Paleoindian occupation of the area is more extensive than current data would suggest. The documentation of Paleoindian projectile points manufactured from Pedernal chert as well as from Jemez obsidian suggests that early hunters and gatherers used lithic sources in the Jemez area as early as Clovis times.

The recovery of Paleoindian artifacts in association with extinct forms of Pleistocene megafauna initially led to the conclusion that Paleoindian groups subsisted primarily on big game. Subsequent research on Paleoindian settlement and subsistence indicates that it may be reasonable to portray early man as a more generalized hunter and gatherer (McGregor 1965, Willey 1966), though big-game hunting was clearly a critical component in the seasonal round of hunting and gathering activities.

Three major divisions of Paleoindian adaptation have been proposed, based primarily on the appearance of a series of diagnostic projectile point types. The Clovis of the Llano phase has generally been dated to 9500–9000 B.C. (Irwin-Williams 1965, Irwin-Williams and Haynes 1970). The succeeding stage of adaptation, called Folsom, has been dated to approximately 9000–8000 B.C. (Agogino 1968, Judge 1973) and marks a trend toward specialized hunting practices. Folsom materials have frequently been found in association with an extinct species of bison *(Bison antiquus)*. The Plano phase closes the Paleoindian period, and contains a number of distinctive technological traditions. These include the Agate Basin (8300–8000 B.C.) and the Cody complexes (6600–6000 B.C.) (Irwin-Williams and Haynes 1970). Post-Folsom groups appear to have been highly specialized big-game hunters, relying on bison (Stuart and Gauthier 1981). There may have been a return to a more generalized hunting strategy during terminal Paleoindian times as evidenced by the use of more generalized projectile point types.

Paleoindian materials have been documented both east and west of the project area in the Cochiti region (Biella 1977:113) and in the Arroyo Cuervo region (Irwin-Williams 1973). Diagnostic Paleoindian artifacts within the project area have been confined primarily to surface finds of projectile points in association with lithic materials (Reed and Tucker 1983) and a single secondarily deposited cultural horizon of unknown age from Abiquiu Reservoir (Schaafsma 1976:52–53).

Paleoindian materials have been recovered during Public Service Company's (PNM) Ojo Line Extension project at site number OLE 55, where a Clovis projectile point and other Paleoindian materials have been recorded in association with a large lithic artifact scatter. At another site (OLE 43) an Eden phase projectile point midsection was present, associated with a lithic artifact scatter, and several Paleoindian projectile points have also occurred as isolated finds (Acklen et al. 1990:57). In general, Paleoindian materials are poorly represented in the northern Rio Grande drainage, and rare at high altitudes.

Archaic Period

The Archaic stage of adaptation succeeds the Paleoindian period, and refers to a time of migratory hunting and gathering groups employing a seasonal pattern of wild plant and animal exploitation. Irwin-Williams (1968) feels that Paleoindian groups withdrew from the northern Southwest to the north and east, and that the Archaic occupation represents an influx of peoples from the west. Others (Judge 1982, Stuart and Gauthier 1981) disagree and argue for an in situ development of the Archaic tradition out of a Paleoindian base.

Thomas (1973) and Aikens (1970) proposed that the Archaic stage, as it is manifested in the arid West, is synonymous with the term "Desert Culture" (Jennings 1964). The Desert Culture concept has been described as a widespread, uniform culture characterized by a hunting and gathering way of life between 8000 and 3000 B.C. (Martin and Plog 1973:78); however, at least two traditions and several successive stages of adaptation have been defined within the Desert Culture.

As defined on the basis of sites in southeastern Arizona, the Cochise tradition (Jennings 1964, Sayles and Antevs 1941) is composed of three projectile point morphologies: the Sulphur Springs stage (8000 B.C. to 6000 B.C.), the Chiricahua stage (6000 B.C. to 4000 B.C.), and the San Pedro stage (1900 B.C. to A.D. 1). Early pit structures first appear during the San Pedro stage. No pottery occurs during any of these stages, although limited agriculture can be inferred from the presence of maize recovered from Chiricahua phase contexts at sites such as Bat Cave (Dick 1965) and Danger Cave (Jennings 1957).

Beckett (1973) defines the Cochise Culture area as bounded by southeastern Arizona on the west, Interstate 40 on the north, the San Andres Mountains on the east, and northern Mexico on the south. Laterally thinned projectile points, however, have been recorded throughout the Colorado Plateau and elsewhere in Utah and Wyoming, suggesting that the Cochise tradition may have had its origins in northern Mexico, evolving into a generalized hunting and gathering tradition with independent localized variants.

The Chiricahua phase has been radiocarbon-dated between 3000 and 1500 B.C. in southeastern Arizona and western New Mexico at sites such as Bat Cave (Dick 1965), Wet Leggett site (Martin et al. 1949), and the Moquino site (Beckett 1973). Projectile point forms typically have concave bases and side notches high up on the lateral margins of the point.

San Pedro projectile points are quite varied with shallow corner-notched and side-notched types. Oval pit structures with central hearth features and associated storage pits were first occupied during the San Pedro phase (Sayles 1945). The Cochise tradition terminates between 100 B.C. and A.D. 400, and is succeeded by Mogollon I and Pioneer Hohokam in southeastern Arizona (Willey 1966), but appears to persist late in south-central New Mexico with the Mesilla phase of the Mogollon (Lehmer 1948).

In contrast to the Cochise tradition, the Oshara tradition, defined in the Arroyo Cuervo region near Albuquerque, appears to include the Archaic occupants of the fire effects study project area on Holiday Mesa. The Oshara tradition began around 5500 B.C. and ended around A.D. 400 (Irwin-Williams 1970, 1973, 1979). It is generally divided into Early Archaic (Jay, Bajada, and San Jose phases), and Late Archaic (Armijo and En Medio phases) based on the introduction of limited maize horticulture during the Armijo phase.

The Early Archaic sites consist primarily of small, limited base camps (Moore and Winter 1980, Vierra 1980). Population size appears to have been relatively stable during the Jay and Bajada phases (5500 to 4800 B.C., 4800 to 3200 B.C., respectively), based on the increase in both the size and number of sites, located primarily in canyon heads. During the Armijo phase (1800 to 800 B.C.) the settlement pattern seems to replicate that of the Early Archaic except for a seasonal population aggregation at canyon heads accompanied by a slight decrease in the total number of sites. Domesticated plants mark a significant change in the range of subsistence resources used. During the En Medio phase (800 B.C. to A.D. 400, Late Archaic/Basketmaker II period), the population increased significantly, reflected in much higher site densities. Seasonally occupied base camps show evidence of repeated occupations, accompanied by a pronounced seasonal pattern of aggregation of bands at base camps followed by dispersal into microbands.

It should be noted that the chronology outlined by Irwin-Williams (1970, 1973, 1979), while generally useful in northern New Mexico, deals primarily with the Arroyo Cuervo region of New Mexico and may not be directly applicable to Archaic period adaptations in the study area. It is, however, a useful and enduring frame of reference.

Although there are relatively few material remains from Paleoindian cultures in the Jemez study area and surrounding regions, Archaic materials are comparatively abundant. As early as 1934, for example, Frank Hibben recorded lithic artifact scatters measuring several acres in extent on the terraces adjacent to the Río Chama (Hibben 1937). Numerous Archaic period lithic artifact scatters were recorded during the School of American Research Abiquiu Project. Snow (1983) recorded 176 sites of Late Archaic affiliation; Archaic-Basketmaker II sites account for the single most common site type in the vicinity of Abiquiu Reservoir (Schaafsma 1975, 1978). Beal (1980:7) notes that the larger Archaic sites in the Abiquiu region exhibit evidence of site reoccupation

in the form of multiple hearths and projectile point styles that span multiple time periods. Warren (1974) recorded several sites containing diagnostic artifacts, suggesting that Bajada through Basketmaker II occupations are located along the west slope of Cerro Pedernal. During the San Juan to Ojo survey, Enloe et al. (1974) documented a number of ceramic and lithic artifact scatters located adjacent to the lower Río Chama Valley and in the Piedra Lumbre Valley, one of which (site number LA 11836) was excavated by Snow (1983). Lang (1979) recorded 7 lithic artifact scatters with Late Archaic or Basketmaker II materials near the confluence of the Río Chama and the Ojo Caliente River. The Pajarito Archaeological Research Project (PARP) recorded 20 Archaic lithic artifact scatters, including 9 dating to the Early Archaic (Hill and Trierweiler 1986). In the White Rock Canyon area, the initial Cochiti survey located 121 nonstructural proveniences within 90 site locations that were tentatively assigned to the Archaic period. Intensive investigation of a number of these sites resulted in data that suggest short-term residential occupation by very small groups during the Late Archaic period (Lang 1979:72).

During the Baca Geothermal Project (Baker and Winter 1981), excavation of 21 sites revealed evidence of bifacial tool production using obsidian gathered from local Jemez obsidian sources. The majority of these sites dated to Late Archaic/Basketmaker II times; however, the authors concluded that the earliest use of the area may not have been defined by Oshara materials, but may be associated with the Cochise Culture (Chiricahua phase) laterally notched projectile points. In the Caja del Río area, materials have been reported by Campbell and Ellis (1951), Frisbie (1967), Reinhardt (1967), Chapman (1979a, 1979b), and Irwin-Williams (1967, 1973). Several Archaic sites were intensively excavated by Irwin-Williams (1967), particularly sites LA 9500 and LA 9501.

Excavations from a Late Archaic pit structure and associated surface structure near San Ildefonso Pueblo at the base of the Jemez Mountains (Lent 1991) have yielded radiocarbon dates from the hearth and floor of the structure suggesting an occupation around 2490 and 1950 ± 70 years, and are partially corroborated with obsidian dates. The preponderance of the radiocarbon dates suggest the major use of this site occurred around 500 B.C. Faunal remains and ground stone were recovered in association with En Medio materials (800 B.C. to A.D. 400). Incipient horticulture may have been practiced at this site.

Nearby, along NM 502, Moore (1989) is completing investigations of a series of Archaic features and a lithic artifact workshop probably dating to the Middle and Late Archaic/Basketmaker II (BM II) periods (LA 65006).

Thirty-eight sites were assigned to the Early, Late, and generalized Archaic category during PNM's Ojo Line Extension project (Acklen et al. 1990:57).

Anasazi Period

The Puebloan occupation of the region by the Anasazi has commonly been classified according to the Pecos scheme (Kidder 1927) and also by the more geographically specific Upper Rio Grande sequence (Wendorf and Reed 1955).

Evidence of Developmental period occupation of the project area is scant (roughly equivalent to Kidder's Pueblo I and Pueblo II periods, ca. A.D. 600–1200). The Pajarito Archaeological Research Project (PARP) recorded a single Developmental site in an 11 percent sample of 621 sq km on the Pajarito Plateau (Hill and Trierweiler 1986). The lack of Developmental period habitation sites strongly suggests a hiatus in occupation between the Late Archaic and the Early Coalition periods (i.e., middle Pueblo III). Occasional surface finds of Basketmaker III/Pueblo I phase projectile points suggest that Developmental period use of the Jemez may be restricted to seasonal hunting episodes.

There is much more direct evidence for residential Coalition period occupation within the study area (roughly equivalent to Kidder's Pueblo III period, ca. A.D. 1200–1325). The Coalition period is marked by significant population growth and an expansion of permanent year-round settlement by Anasazi agriculturalists into high-altitude areas. Information on sites of this period has been obtained primarily through the excavations conducted at Riana Ruin (Hibben 1937), the Leaf Water site (Luebben 1953), and Palisade Ruin (Peckham 1959, 1981). These communities have been tree-ring dated to the early and mid–1300s (Anschuetz et al. 1985:9). Excavations in the Abiquiu area on Coalition period sites include LA 11830, a seasonally occupied fieldhouse and garden plot complex (Enloe et al. 1974, Fiero 1976), and LA 20325, a large garden complex (Lang 1979, 1980, 1981). Peckham (1981:134) reports that habitation settlements were typically widely scattered along the Río Chama and its tributaries during the Coalition period. However, he views placement of the Palisade

Ruin, which is located on a high mesa overlooking the Chama drainage, as evidence that demographic factors compelled agriculturalists to exploit areas previously considered marginal for agriculture (see Anschuetz 1984:10, Peckham 1981:136–138).

The Pajarito Plateau area around Los Alamos and Baca Location No. 1 were used during Basketmaker III times, followed by a hiatus during the Developmental period, similar to that which occurred within the lower Chama/Abiquiu Reservoir districts. Although Anasazi structural sites are generally scarce above altitudes of 6,380 ft (2,130 m), large structural sites are present within the Valle Grande and San Antonio Valley areas (Hewett 1906:51), and caves along Sulphur Springs and San Luis Creek have yielded ceramics and corn (Whitford and Ludwig 1975). Several surface scatters from the Coalition period were investigated during the Baca Geothermal Project (Baker and Winter 1981), suggesting intermittent use of this area throughout Pueblo II-IV times. Jemez Cave was occupied until ca. A.D. 1300 (Ford 1975). Interestingly, as the number of residential sites increased during Coalition times, the evidence of Coalition period dates on limited-use sites in the Abiquiu area declined. Obsidian hydration dates from multicomponent lithic artifact scatter in the Abiquiu area exhibit very few Coalition period dates (Bertram et al. 1987).

Numerous Anasazi sites were investigated during the Cochiti Project in White Rock Canyon. Although all phases of the Rio Grande sequence are represented within the Cochiti study area, the first settlements date to the Coalition period. Data from a sample of 92 small structural Pueblo III sites and 139 Pueblo IV sites from the Cochiti study area indicate a decrease in mean room size from Pueblo III times to Pueblo IV times. These differences "may indicate a change in the function of small structural sites coincident with the trend towards large aggregated settlements" (Hunter-Anderson 1979:177).

In the Gallina District in northern New Mexico, significant settlement begins after A.D. 1200. This district, which has been described as geographically isolated and culturally conservative (Cordell 1979:46), is characterized by numerous pithouse villages, small surface masonry structures, and towers frequently placed in "defensive" locations. The towers probably served as storage structures (see Anschuetz et al. 1885, Dick 1976, Whiteaker 1976). Terraced gardens and rock-bordered grid gardens are common, and dams and reservoirs have been identified. Pithouses frequently show evidence of burning. This, coupled with apparently defensive locations and fortifications, has led investigators to postulate that much internecine conflict was occurring within the Gallina area. Pithouse architecture persists into the 1500s, and diagnostic ceramic types (Gallina Black-on-white, as well as corrugated plain ware varieties) remain virtually unchanged for at least 300 years.

The Classic period post-dates the abandonment of the San Juan Basin by sedentary agriculturalists (roughly equivalent to Kidder's Pueblo IV period, ca. A.D. 1325–1600). It is characterized by Wendorf and Reed (1955:153) as a time when regional populations attained their greatest levels: large communities with multiple plazas, kivas, and room-block complexes were occupied, and material culture underwent substantial elaboration. The beginning of the Classic period in the northern Rio Grande coincides with the appearance of locally manufactured red-slipped and glaze-decorated ceramics, the Glaze A wares, in the Santa Fe, Albuquerque, Galisteo, and Salinas districts after ca. A.D. 1315 (Mera 1935, Warren 1980). The large Biscuit ware sites of the Chama District and the Pajarito Plateau have been the subject of archaeological investigations since the turn of the century. Tree-ring specimens were collected from Tsiping, Howiri, and Homayo in the 1930s (Hewett 1953). Investigations of Classic period sites in the Chama District consist primarily of limited contract projects at Ponsipa-akeri and excavations of portions of Howiri within the US 285 construction right-of-way (Fallon and Wening 1981).

Schaafsma (1979:21) characterizes the Anasazi occupation of the Río Chama Valley during the Classic period as a pattern of gradual withdrawal downstream towards the Rio Grande. The Piedra Lumbre Valley appears to have been the northwestern extension of Anasazi settlement; however, survey and excavation work indicate that is was apparently abandoned by A.D. 1400 (Hibben 1937, Mera 1934, Schaafsma 1979). Mera (1934:19) and Wendorf (1953:94, Wendorf and Reed 1955:153) argue that this contraction of settlement culminated shortly before A.D. 1600 with the abandonment of the entire district by permanent year-round Anasazi agriculturalists. Mera (1934:18) cites the absence of any mention of the numerous ruins in the region as evidence that the communities were no longer occupied at the time of the Spanish *entradas*.

Whether the large Pueblo IV sites were occupied on a year-round basis at the time of European con-

tact is somewhat problematic. Ellis (1975:20), citing the presence of sheep and cattle bones at Sapawe, and a piece of metal from Tsama, believes they were occupied after contact. Schaafsma (1979:22) feels that the historic artifacts may only represent seasonal use of these sites by Pueblo herdsmen.

Only a single Classic period site was investigated during the Baca Geothermal Project (Baker and Winter 1981:v): "This represented a single component Pueblo IV location; it differs from the other ceramic sites in its absence of bifacial tool production and its high diversity of artifact types." This site was tentatively dated A.D. 1331 through obsidian hydration (mean hydration value of 1.2 microns). Significantly, very few Classic dates were obtained from the obsidian hydration analysis on multicomponent scatter sites in the Abiquiu area (Bertram et al. 1987).

During the survey of Cochiti Reservoir (Biella and Chapman 1977), 13 multicomponent Pueblo III/Pueblo IV sites and 86 single-component Pueblo IV proveniences were located. One 200–300 room pueblo was documented. Eight sites were nonstructural lithic and ceramic scatters, eight were terraces, and three were structures of four or more rooms. The ceramic assemblages were characterized by a greater frequency of painted ware vessels than utility ware vessels. Of the multicomponent Pueblo III/Pueblo IV sites, the majority exhibited two to three rooms each. In the absence of diagnostic artifacts, 83 site locations with 110 proveniences were tentatively assigned to the Anasazi period based on architectural similarities with datable Anasazi site locations.

Historic Period

Protohistoric Occupation

Despite much research, it is not certain when the first southern Athabaskan peoples entered the Southwest. Dates have been suggested as early as A.D. 1000 (Kluckhohn and Leighton 1962) and as late as A.D. 1525 (Gunnerson 1956). It seems probable that by the early sixteenth century Athabaskan-speaking groups that had migrated southward from points in northern Canada were established on the plains of Texas and New Mexico (Gunnerson 1956, 1969, Gunnerson and Gunnerson 1971, Hester 1962, Vogt 1961).

The first area that the Navajos may have settled was along the upper San Juan River and in Largo and Gobernador canyons (Kelley 1982). Dittert et al. (1961) place the first occupation of the Navajo Reservoir District at 1550, and Keur (1944) dates that of Gobernador Canyon at 1656. Schaafsma (1978) argues that the presence of Navajos in the Chama River Valley between A.D. 1620 and 1710 indicates that Navajos were part of a general movement of Apachean groups into the Pueblo area and that they were not a unique wave of early Athabaskan settlers in northwestern New Mexico.

Navajos shared in the Pueblo Revolt of 1680 (Brugge 1968, Reeve 1959). During the Reconquest, Navajos aided refugees from pueblos to the south. More permanent settlement by the refugee population, by this time probably well mixed with the Athabaskan element, seems to have begun between 1710 and 1715 in the tributary canyons of the San Juan. Sites of this period are characterized by *pueblitos*, small pueblo-style structures of one or more rooms, usually built in defensive locations and with associated hogans, towers, and defensive walls (Carlson 1965). Pottery of this time period includes Dinetah Utility, Gobernador Polychrome, and nonglaze trade polychromes. During this phase, which ends around 1800, there was a shift from forked stick hogans to stone masonry and cribbed log hogans. Domesticated livestock, such as horses, cattle, and sheep, were also adopted.

There is some linguistic evidence to suggest that Navajos occupied the Pajarito Plateau during early historic times (Harrington 1916) in areas adjacent to the Tewa villages of Santa Clara, Tesuque, Pojoaque, San Juan, Cochiti, and San Ildefonso. The Navajos are described as living in *rancherias* and practicing agriculture (with large planted fields) as well as animal husbandry (see Ayer 1916, Hodge et al. 1945). In Navajo cosmology, Redondo Peak is considered one of the sacred eastern mountains, and Navajos are known to have made pilgrimages to its top (Baker and Winter 1981). It is probable that the Navajos also utilized the lithic resources at Polvadera and Pedernal peaks throughout the seventeenth and eighteenth centuries. The survey of Abiquiu Reservoir by the School of American Research recorded 33 sites believed to be historic Navajo settlements ranging from habitation sites to lithic and ceramic scatters located on the second or third benches of the Chama. These Piedra Lumbre sites may also be attributed to the Tewa, Hispanics, or other groups (Bertram et al. 1987, Kemrer 1987).

Charles Carrillo (pers. comm. 1988) has suggested that the stone masonry circular to subrectangular Piedra Lumbre structures reflect a pastoralist adap-

tation as opposed to a cultural indicator of Navajo occupation as suggested by Schaafsma (1976). Carrillo cites documentary evidence supporting a pastoral adaptation on the part of Tewa peoples before the wholesale adoption of that subsistence practice on the part of the Navajo.

By the beginning of the eighteenth century, when Spanish settlement extended into the Chama, it is apparent that Navajos were being pushed westward by a combination of Spanish pressure from the south and Ute pressure from the north and east (Anschuetz et al. 1985). Conflict between Spanish and Navajos was acute throughout the late eighteenth century. Constant Navajo raiding of *rancherias* and their depredations of Spanish sheep flocks resulted in the fortification of Spanish homesteads with stockades and *torreones* (fortified towers).

Lodge sites are numerous in the Chama area and are generally ascribed to the Navajo or Ute (Hibben 1937). Another group that visited the valley was the Guaguatu or Capote Utes, mentioned by the Jemez Pueblo Indians in a Spanish account dating to 1626 (Schroeder 1965:54).

Hispanic Occupation

Following the Spanish reconquest of New Mexico in 1692–1696, the northernmost frontier of Mexico was resettled (Snow 1979). The seventeenth and eighteenth centuries saw a rapid increase in the number of Spaniards who wanted to settle in the colony. Within the Abiquiu Reservoir District, Schaafsma (1976) investigated 14 Spanish sites, including 5 Territorial period homesteads in the Puerco Valley. The typical homestead has a two- or three-room house, corrals, and outbuildings, perhaps including subterranean facilities and outdoor ovens. Artifacts are glass, china, crockery, metal, Tewa black or red pottery, and micaceous pottery, indicating occupation in the late nineteenth and early twentieth centuries (Schaafsma 1978:24). Ceramics from the Colonial phase sites consists of ollas, bowls, and jars from the Rio Grande pottery centers as well as from the Zía area. The question of an indigenous Spanish pottery tradition is somewhat problematic. It has been suggested that Mexican Indians brought in by Spanish immigrants may have produced pottery using identifiable Mesoamerican techniques (Hurt and Dick 1946, Riley 1974). Many vessel forms from Historic period ceramics, such as hemispherical bowls, ring bases, and soup-plate forms, appear to reflect Spanish design influence (Dick 1968). In fact, Carrillo (1987) argues that much of the pottery attributed to Rio Grande Pueblos in the Abiquiu area may be locally manufactured by Hispanics as late as the 1940s.

Since the introduction of sheep by Oñate's colonizing expedition in 1598, sheepherding has played an important role in the economy of Hispanic people (Carlson 1969:28). In an effort to manage the large herds, rich landowners *(ricos)* developed the *partidario* system in which flocks of sheep were put out on shares to individual sheepherders. These *partidarios* were required to return between 10 and 20 percent of each year's increment and the same amount in wool to the owner. Although this system potentially allowed individual sheepherders to start their own flocks and become independent, it usually led to perpetual debt and promoted an inequitable class system. The high pastures of the Jemez Mountains have historically provided excellent grazing for flocks during their summer upland cycles. The original Baca Land Grant of 1821 was used for running sheep and not for cultivation. At one time, 3,000 sheep and an undetermined number of cattle were said to be on the grant. A history of the Baca Land Grant is provided by McPherson (1978) and describes turn-of-the-century sheepherding practices. In 1920, the Redondo Development Company sold the grant area to Frank Bond, who allowed sheep to run on his land. Much of the graffiti recorded during the Baca Geothermal Project and carved into aspen trees is from Bond's period of ownership. Similar graffiti was observed during the OLE (Acklen et al. 1990) survey as well.

PHASE I ARCHAEOLOGICAL FIELD WORK AND METHODS

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Prior to fieldwork, OAS archaeologists were briefed by Forest Service fire experts on various aspects of fire behavior (April 7, 1992). On May 5, 1992, on-site inspection of burned sites and fuel model areas in the Mud Springs area took place. This was followed by a reconnaissance of the Henry Fire area (on Holiday Mesa), accompanied by the Forest Service archaeologist to gather observational data relevant to fire temperature, fire line intensity, and flame length (May 14, 1992).

Research Framework

The following research questions were addressed to understand the effects of fire on cultural resources. The results will be used to better protect cultural resources in wildfire and prescribed burn situations (summarized from Cartledge 1992). These included:

1. What set of techniques can be developed to objectively assess and document the effects of fire on cultural resources? What techniques would be most efficient in actually measuring these variables in experimental situations?
2. What criteria can be used to objectively evaluate and document the nature of site and artifact damage?
3. How can the effects of fire of varying intensities on different artifact and feature classes be determined?
4. What is the threshold (temperature, fire intensity, etc.) at which significant damage to cultural resources occurs?
5. What is the most consistent way of predicting the effects of fire on cultural resources based on fuel characteristics, fire characteristics, the nature of cultural resources, and other variables?
6. Are there effective ways of protecting cultural resources in wildfire and prescribed burn situations? What set of guidelines can be recommended to help land managers protect cultural resources in wildfire and prescribed burn situations?
7. Do changes in the site's artifactual content brought on by fire alter the data relevant to answering the questions important to the study of prehistory that a study of an unburned site could have provided? Under what circumstances, if any, do fire effects temporarily or permanently inhibit the information potential of the site (e.g., destroying perishable features, obscuring diagnostic artifacts, altering chronometric features)?

To address these questions, a two-phase research strategy was developed. Phase I was designed to focus on the effects of the Henry Fire on cultural resources in the Santa Fe National Forest and make preliminary management recommendations. Phase II will be implemented to test the findings and hypotheses generated by the Henry Fire study and the Phase I findings in one or more controlled fire situations.

The main purpose of the Phase I study was to test the relationship between fire characteristics, as reconstructed from field observations, and fire effects on cultural resources, based on post-fire field observations and laboratory analysis. The results will be used to formulate preliminary models to:

1. Develop a set of objective field techniques to measure and classify fire characteristics and effects on cultural resources in a post-fire context (fire experts are able to retrodict fire-line intensity and flame length following a fire).
2. Determine the effects of different fire intensities on different types of cultural materials through laboratory analyses.
3. Determine the threshold at which significant damage starts to occur relative to different types of cultural materials.
4. Produce information on the ability to identify duff-covered cultural resources by comparing pre-fire and post-fire survey results; produce information on the function of small prehistoric structural sites previously covered with duff by documenting artifacts associated with these structures.
5. Develop a predictive framework, through application of the results of the above analyses, for anticipating and predicting the effects of fire on cultural resources. This framework will be tested further in Phase II of the project.

6. Develop objective criteria through which it can be determined at what point the data potential of a site is altered through exposure to fire.
7. Determine the degree to which burning archaeological sites inhibits accurate evaluation of data potential with respect to current federal legislation, specifically Section 106 of the NHPA, 36 CFR 800 (criterion D) and other pertinent state and federal regulations.

To summarize, Phase I was designed to address questions 1–7 (above). It was expected that only part of these questions could be answered during Phase I, and only in a preliminary fashion. Phase II would further seek to address and expand upon the questions that may have only been partially answered during Phase I. It was also expected that questions exclusively relevant to Phase II would be generated.

Data Collection

Field Methodology

Based on preliminary observations from the 1991 USFS resurvey, the sites on Holiday Mesa were grouped into three fire intensity categories. Seven sites were selected to be tested during Phase I according to observed artifact densities and intensity of burning (table 5). Two sites were selected in each of the three burn categories. One control site was investigated in a nonburn area. These sites (identified by their USFS site numbers) were AR-03–10–03–1905, moderate intensity; AR-03-10-03-1930, heavy intensity; AR-03–10–03–1961, light intensity; AR-03-10-03-2513, moderate intensity; AR-03–10–03–1931, heavy intensity; AR-03-10-03-2516, light intensity; and AR-03-10-03-1886, the unburned control site. In subsequent text and table references, the 03–10–03 designations are omitted from the site numbers.

Once these sites were selected, the following procedures for data collection were observed:

1. A main site datum was established at each site. This fixed reference point was marked with metal rebar. All horizontal and vertical controls were made with reference to this datum, which measured 0.0 meters below datum (mbd) (fig. 4).
2. Each site was mapped using a Brunton compass mounted on a tripod.
3. Each site was divided into quadrants with 50-m tapes.

Table 5—Descriptions, burn intensities, and work performed at the study sites.

Site number	Burn intensity	Site description and work performed
AR-1961	Light	Two-room masonry structure, associated artifact scatter; historic component (not collected); BLA area on midden
		Mapped, one test pit, collected SE quad
AR-2516	Light	Two-room masonry structure, standing wall; associated artifact scatter; BLA area on wall fall
		Mapped, one test pit, collected SE quad
AR-1905	Moderate	One-to-two room masonry structure, associated artifact scatter; BLA on rubble mound
		Mapped, two test pits, collected sample of SE quad
AR-2513	Moderate	Two-room masonry structure, associated artifact scatter; high lithic artifact density; BLA on rubble mound
		Mapped, two test pits, collected SE quad
AR-1930	Heavy	Two rubble mounds: (a) two-room masonry structure, associated artifact scatter; (b) one-room masonry structure, associated artifact scatter; BLA unknown
		Mapped, one test pit, collected sample of SE quad, mapped area b
AR-1931	Heavy	Two-room masonry structure, associated artifact scatter; BLA on rubble mound
		Mapped, two test pits, collected SE quad
AR-1886	Unburned	Two-room masonry structure, associated artifact scatter
		Mapped, one test pit, collected SE quad

Figure 4—Main site datum established with rebar at each site.

4. A sample of artifacts was collected from the southeast quadrant (fig. 5). The site midden was typically located in the southeast quadrant. Artifacts were collected within 1-by-1-m provenience units. A sampling strategy was developed in cooperation with USFS archaeologists to sample sites with abundant materials. If the total number of artifacts in the midden exceeded 200, then the midden collection was limited to the artifacts present in a 100-sq-m area.
5. A 1-by-1-m test pit was excavated within the intensive collection area to a depth of 20 cm to recover subsurface artifacts for comparison with those from the surface. All soil was screened through $^{1}/_{4}$-inch wire mesh. All tests pits contained cultural material.
6. In-field analysis of building elements was conducted to quantify the number of rocks spalled by fire. A measure of severity of spalling was developed. Twelve elements per site were monitored in a 1-by-1-m area in high element density situations and a 5-by-5-m area in low element density situations. Spalling from fire was hierarchically ranked as low, medium, and high. Total spalling for each individual element was estimated on a percentage basis.
7. If a log had burned on top of the structural component (BLA), the planned procedure was to excavate a 1-by-1-m test pit in that area to determine if any features were located below the burn area, and the extent to which subsurface features were burned. The objective was to determine if the chronometric potential of hearths had been compromised through exposure to fire; however, no subsurface features were encountered.

Burned log areas (BLAs) were present on all burned sites except AR-1930, where the burning was so intense that any fuel load may have been entirely

Figure 5—Site gridded into quadrants from the site datum.

consumed (see table 5 for the location of BLAs within the sites). Artifacts collected from areas where logs had burned in situ were placed in bags marked "collected from BLA area."

Laboratory Methodology

Laboratory procedures and analyses of collected materials were conducted by the staff of the Office of Archaeological Studies and qualified professional consultants. These included:

1. The processing of artifacts in such a way as to preserve the attributes needed to determine fire effects. To prevent damage or removal of soot, adhesions, or any other variable related to fire effects, artifacts were not washed or labeled.
2. A typological/functional analysis of ceramic artifacts was performed, including vessel type, vessel form, texture, temper, and paste color and thickness.
3. A typological/functional analysis of lithic artifacts was performed, including morphology, material type, function, cortex, and dimensions.
4. A typological/functional analysis of groundstone artifacts was performed, including preform type, material type, function, and dimensions.
5. A series of variables specifically designed to measure the degree of fire effects for each of the three artifact categories (ceramic, lithic, ground stone) listed above was developed (see specific methodologies, below).

SITE DESCRIPTIONS

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Below are descriptions of the seven sites and the work performed at each site. The six burned sites are discussed first and are listed according to degree of burning to which they were exposed: lightly burned sites—AR-1961 and AR-2516; moderately burned sites—AR-1905 and AR-2513; and heavily burned sites—AR-1930 and AR-1931. The unburned control site, AR-1886, is described last. Dates given under "cultural affiliation" refer to the temporal intervals represented by the ceramic artifacts on the site (e.g., A.D. 1300–1750 are the dates associated with Jemez Black-on-white ceramics).

Lightly Burned Sites

Site Number: AR-03-10-03-1961

Burn Intensity.—Lightly burned

Cultural Affiliation.—Multicomponent Anasazi A.D. 1300–1750; A.D. 1680–1740; Historic Euroamerican 1920s

Work Performed.—The site was mapped, a sample of surface artifacts was collected from the southeast quadrant, isolated lithic and ground-stone artifacts outside of the southeast quandrant were collected, field analysis of tuff building blocks was performed, and one test pit was excavated.

Site Description.—AR-1961 is a multicomponent site that consists of prehistoric (Pueblo IV) and Euroamerican historic components (post–1920s). The site is in an open, flat area within a sparse stand of ponderosa pine. The prehistoric component is a small masonry structure with associated lithic and ceramic artifacts. The historic component of the site is a widely dispersed artifact scatter; the historic artifacts extend further to the north and northeast than the prehistoric artifacts. The remains of the two-room masonry structure (7-by-6.5 m) are composed of shaped and unshaped tuff blocks. A portion of the rubble mound has been modified by the later historic occupants; tuff blocks have been piled on the eastern side of the structure and a large piece of sheet metal has been placed next to it. The site covers a total of 1,419 sq m and measures 33 m north-south by 43 m east-west (fig. 6).

This site is classified as a lightly burned site. The ponderosa pine trees around the structure have been burned 4 ft (1.22 m) above the ground surface, leaving behind green needles on the branches. Duff covers 70 percent of the surface of the site and is the result of new and old pine needle accumulation. One year after the fire, the surface of the site appears not to have been burned. The excavation unit, however, shows that the humus layer had been partly burned during the Henry Fire and a new layer of needles has since been deposited over the site. A burned log is present in the southeast quadrant. This highly burned element resembles the charred logs that were observed on heavily burned sites. It is hard to see surface artifacts except in the area of the burned log. The ground surface around the log has been charred leaving behind an ashy soil with no duff present. The artifacts in the vicinity of the log have been altered by the fire to a greater extent than the rest of the assemblage. The tuff blocks of the masonry structure, for the most part, have not been affected by the fire. Only on the eastern edge of the structure, where the piece of historic metal was located, did the fire generate enough heat to spall and crack the adjacent rock elements.

A grid system was established with 100N/100E located within the masonry structure. A sample of surface artifacts (lithic and ceramic items) were collected within the southeast quadrant (fig. 7). Collection units extended from 99N to 81N and 100E to 123E (456 sq m). The area around the burned log fell within the sample collected. Special attention was taken to label the collected artifacts in this area as BLA to segregate them from the lightly burned area. Additional isolated lithic items and two ground-stone artifacts were collected from the southwest quadrant according to their grid designations. The southwest corner of Test Pit 1 was designated as site datum.

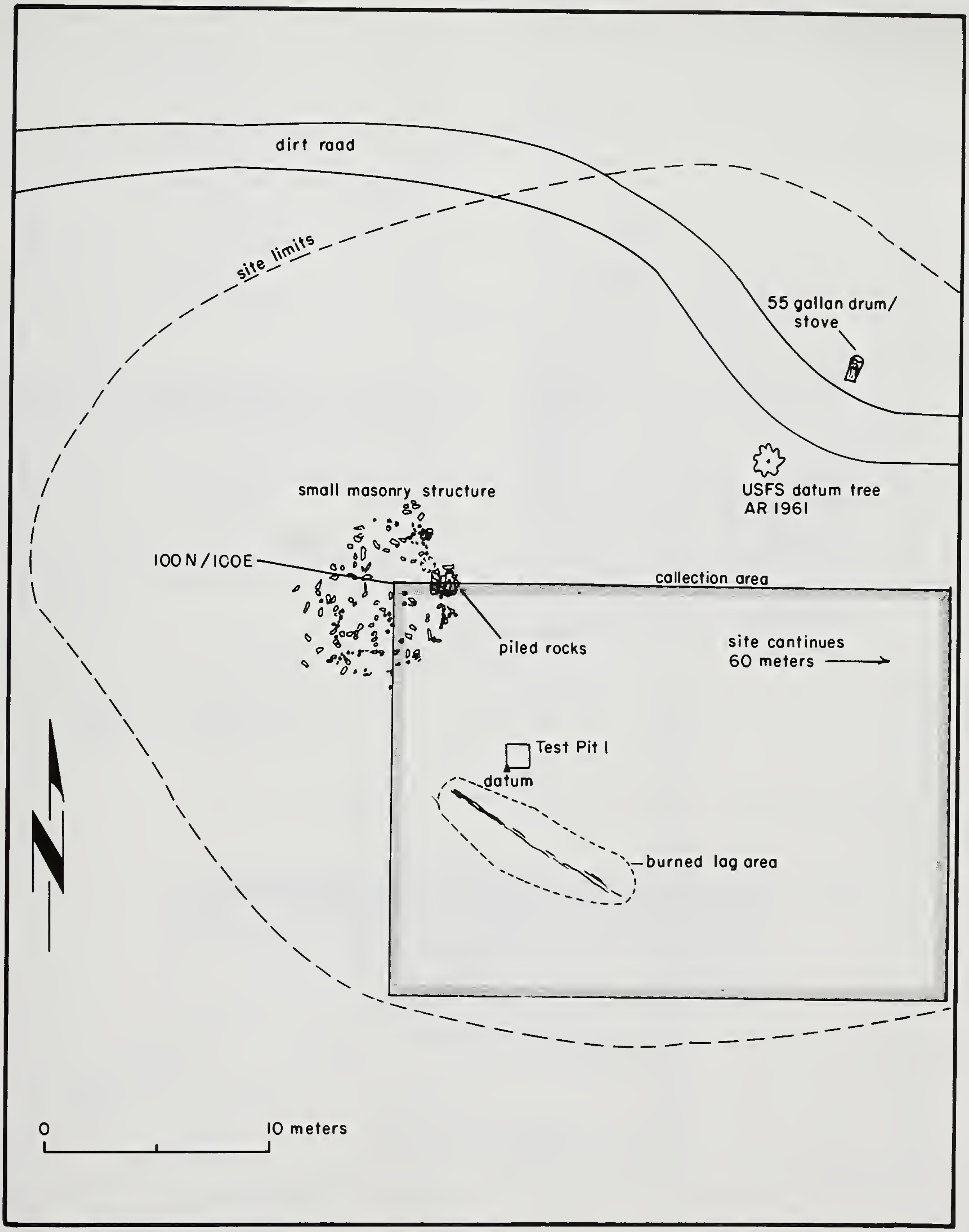

Figure 6—AR-1961, site map.

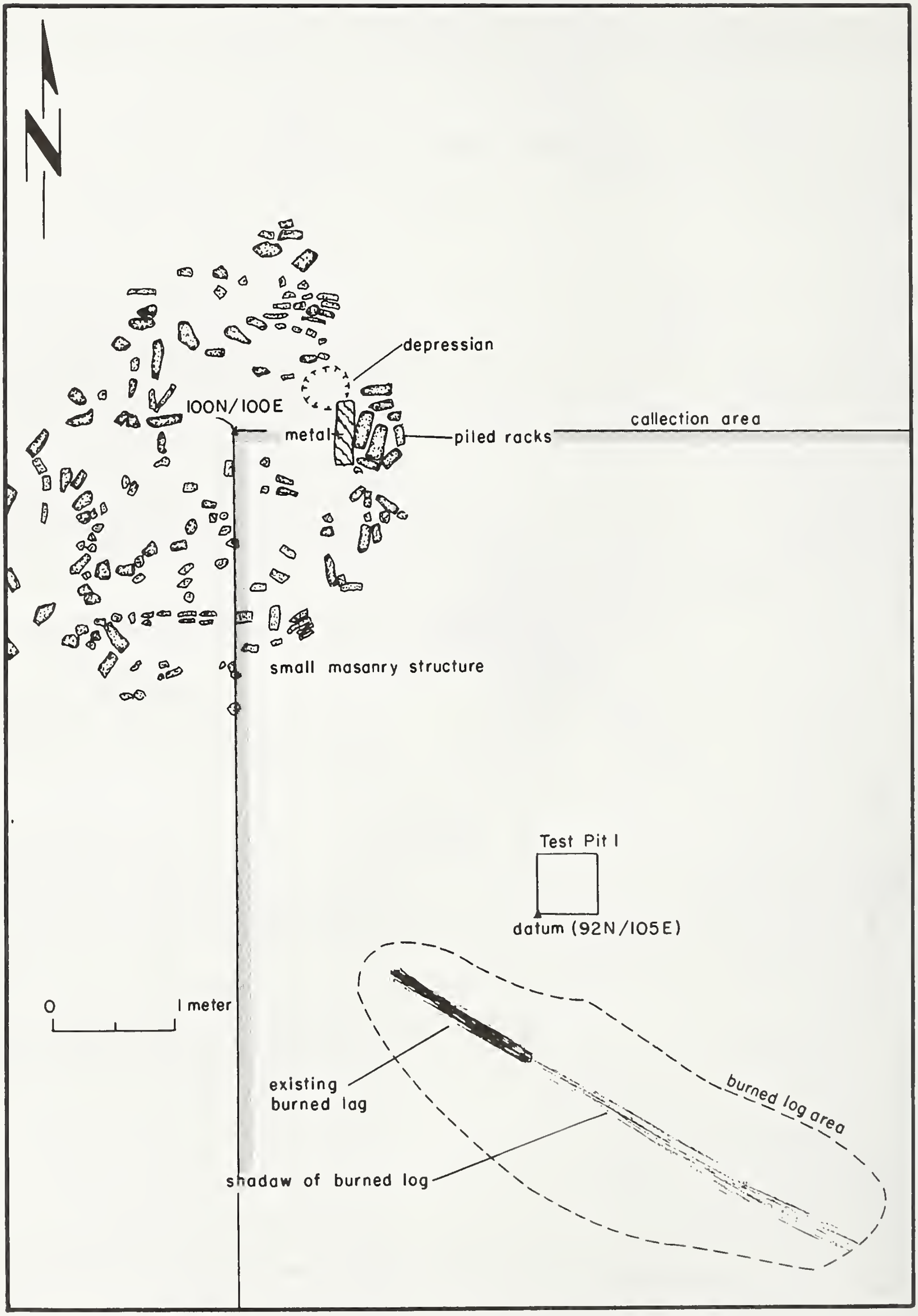

Figure 7—AR-1961, detail of burned log area.

A permanent piece of rebar was left at the location of the datum.

Test Pit 1.—Grid 92N/105E, located 1.5 m north of the BLA, the area of densest artifact concentration within the southeast quadrant. This excavation unit was dug to see if the Henry Fire affected any subsurface depositions. Arbitrary 10-cm levels were dug and three stratigraphic levels were defined. The surface was covered by a light layer of recently deposited needles. The only evidence of burning was in the first centimeter of Stratum 1. The presence of charcoal in Strata 2 and 3 may mean that Test Pit 1 was placed within the midden of the site. Figure 8 is a profile of the south wall of Test Pit 1, and a summary of the stratigraphy follows.

Stratum 1: 10YR3/2, very dark grayish brown. This stratum consisted of a humus layer 4 cm thick. The first centimeter was burned needles while the remaining 3 cm were a very dark grayish brown organic loam (humus layer). Artifacts were recovered in this layer.

Stratum 2: 10YR5/4, yellowish brown. Stratum 2 (7–9 cm thick) was silty clay with charcoal flecks and artifacts. Burning from the Henry Fire did not extend into this layer.

Stratum 3: 10YR4/4, dark yellowish brown. This layer was 10–12 cm thick and consisted of silty clay with fewer charcoal flecks than Stratum 2. No artifacts were encountered in Stratum 3.

Site Number: AR-03-10-03-2516

Burn Intensity.—Lightly burned

Cultural Affiliation.—Anasazi A.D. 1300–1750

Work Performed.—The site was mapped, a sample of surface artifacts was collected from the southeast quadrant, field analysis of tuff building blocks was performed, and one test pit was excavated.

Site Description.—AR-2516 is a collapsed masonry structural site with an associated artifact scatter. It is situated atop a small hill overlooking a drainage to the south. The large number of tuff masonry blocks and the height of the rubble mound suggests this may have been a two-room structure. Five courses of the southwest wall remain standing. The collapsed architecture encompasses an area 9 m north-south by 8 m east-west. The entire site area including the artifact scatter is 30 m north-south by 36 m east-west covering an area of 1,080 sq m (fig. 9). The heaviest artifact concentration, located in the southeast quadrant, was also the collection area.

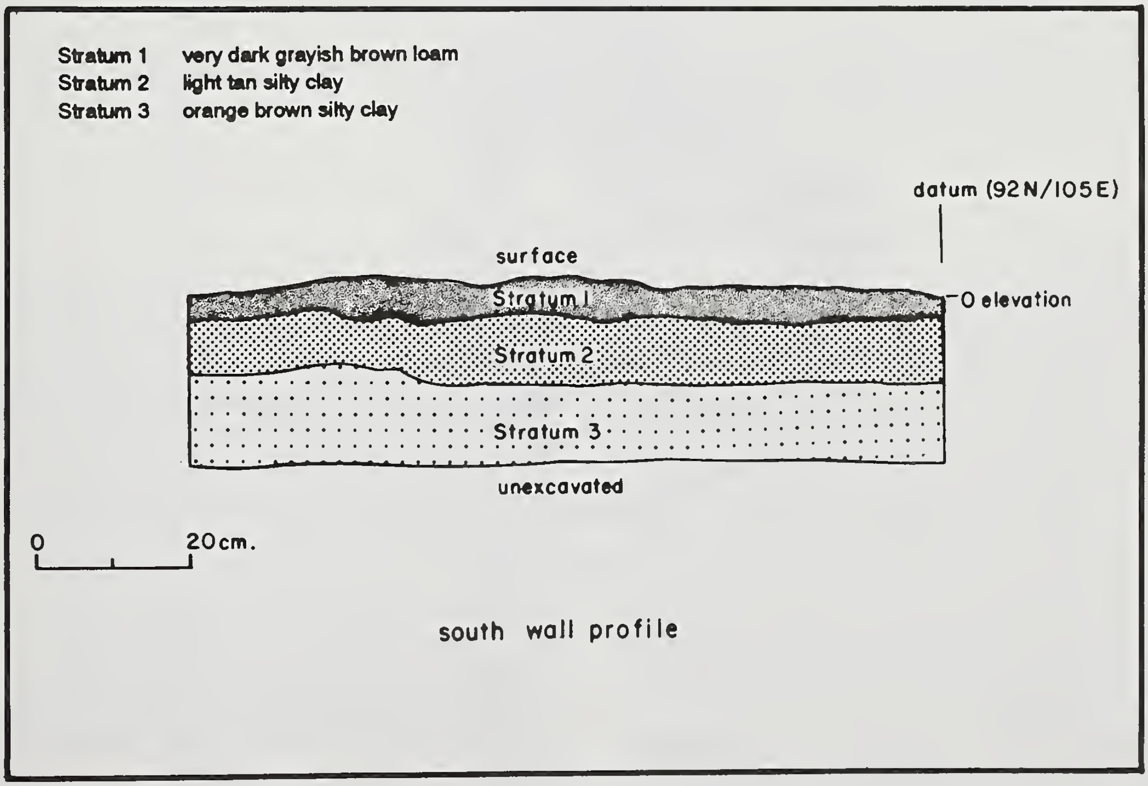

Figure 8—AR-1961, profile of Test Pit 1, south wall.

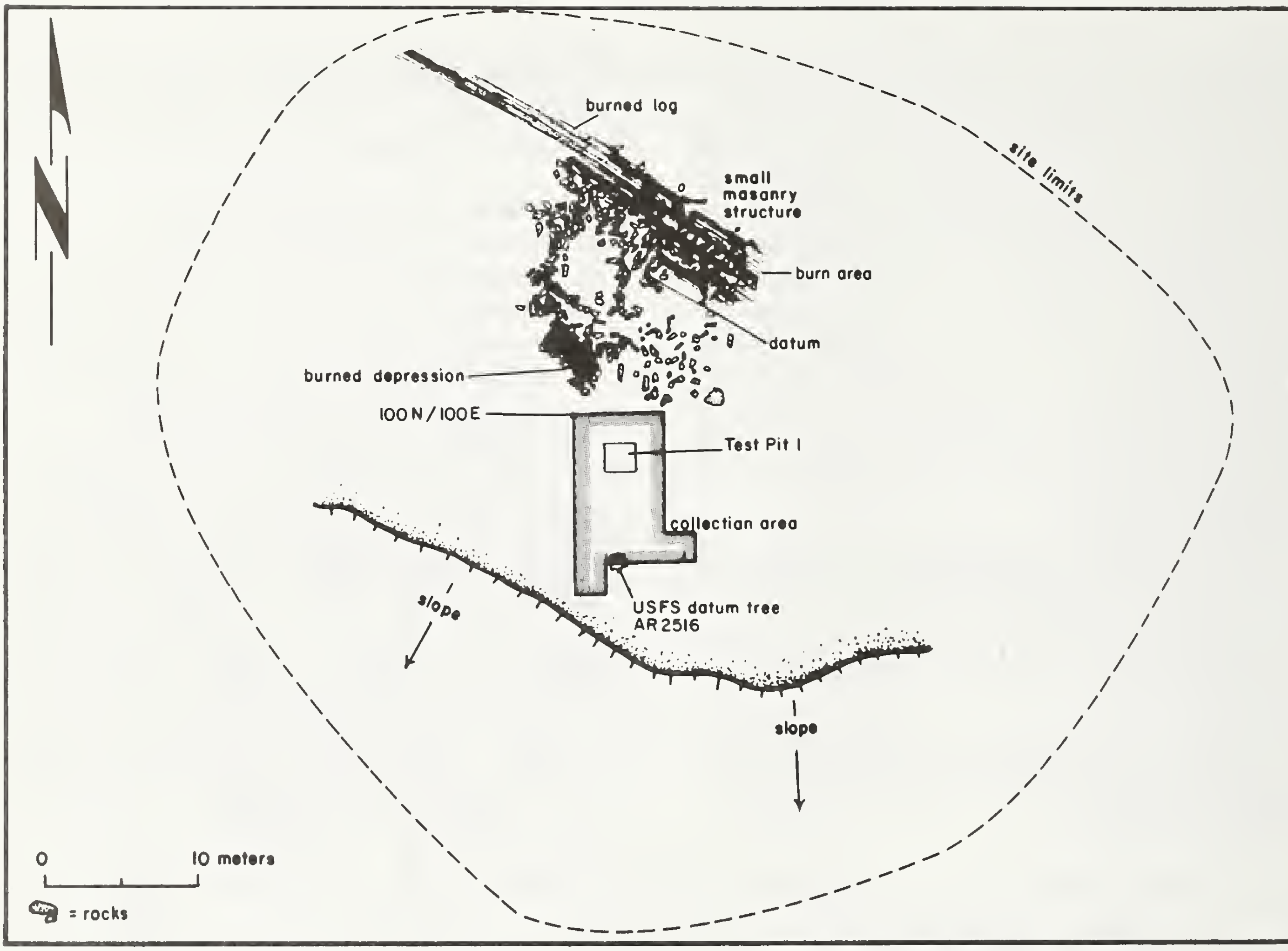

Figure 9—AR-2516, site map.

This site was lightly burned in the Henry Fire. The trees were burned to a height of 1 m (3.3 ft) and green needles still remain on the top of small ponderosa pine trees. The humus layer was burned and new needles have fallen to the ground. Thirty percent of the tuff building blocks have been fire-altered. On average, the rocks were lightly spalled except where the fire had concentrated at the base of trees or where a log had burned across the structure. Here the tuff elements were highly altered by intense heat and exhibited the same burned characteristics as those found on highly burned sites; the tuff was blackened, oxidized, and exploded.

A large tree had fallen on top of the northern portion of the mound and completely burned; its residence time generated extensive damage to the underlying masonry elements. According to the research design, excavation was to be conducted if a log burned across the rubble mound. The log had burned over an area of wall fall and a decision was made to leave the structural elements in place. A detailed analysis of the burned area was documented. The northeast edge of the mound, a 7-by-1-m area, was exposed to intense heat. The majority of the stones within the shadow of the burned tree were blackened and reddened, while a few had been heated to a white friable condition. Five stones had burst apart and others were reduced to pea-sized crumbly tuff. One tuff stone had been completely oxidized and was significantly redder than the adjacent stones. Parts of other stones had deteriorated to powder.

The main site datum rebar was placed in the center of the collapsed architectural feature. An arbitrary

elevation of 0.0 m was 10 cm above the ground surface at the site datum. Another stake, 100N/100E, was placed to the southwest of the main datum. It was from this point that the site was divided into quadrants. A grid system was established and the artifact sample was collected from the southeast quadrant. The collection area included 95N to 99N and 100E to 102E (15 sq m), as well as two adjacent grids. Duff was removed from the grid units to maximize the visibility of artifacts. One test pit was excavated within a dense artifact concentration in the collection area (fig. 10).

Test Pit 1.—Grid 98N/101E was placed within the southeast quadrant. The northeast corner was 61 cm below the site datum. The only evidence of burning from the Henry Fire was the lack of duff and the presence of a gray ashy topsoil. This excavation unit was dug to determine the effects of any subsurface burning. Figure 11 is a profile map of the north wall showing two strata. Strata descriptions are provided below.

Stratum 1: 7.5YR2/0, black. This stratum (2–3 cm thick) consisted of a thin layer of burned loamy soil. Tuff bedrock began outcropping 3 cm below the surface in the southwest corner. Deteriorated welded tuff cobbles comprised 50 percent of the soil matrix. A large root and burned organic material were present just below the surface. Cultural materials were recovered in this layer.

Stratum 2: 10YR3/3, dark brown. This layer varied between 4 and 15 cm thick and consisted of a

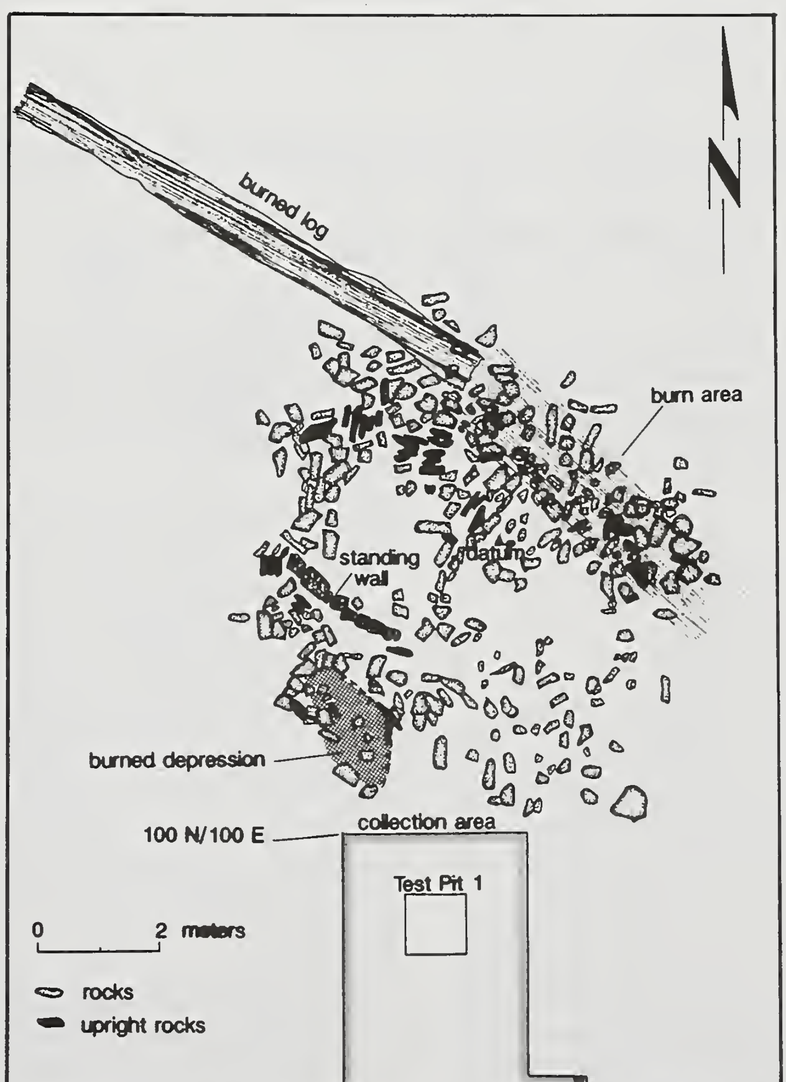

Figure 10—AR-2516, detail of structure and burned log area.

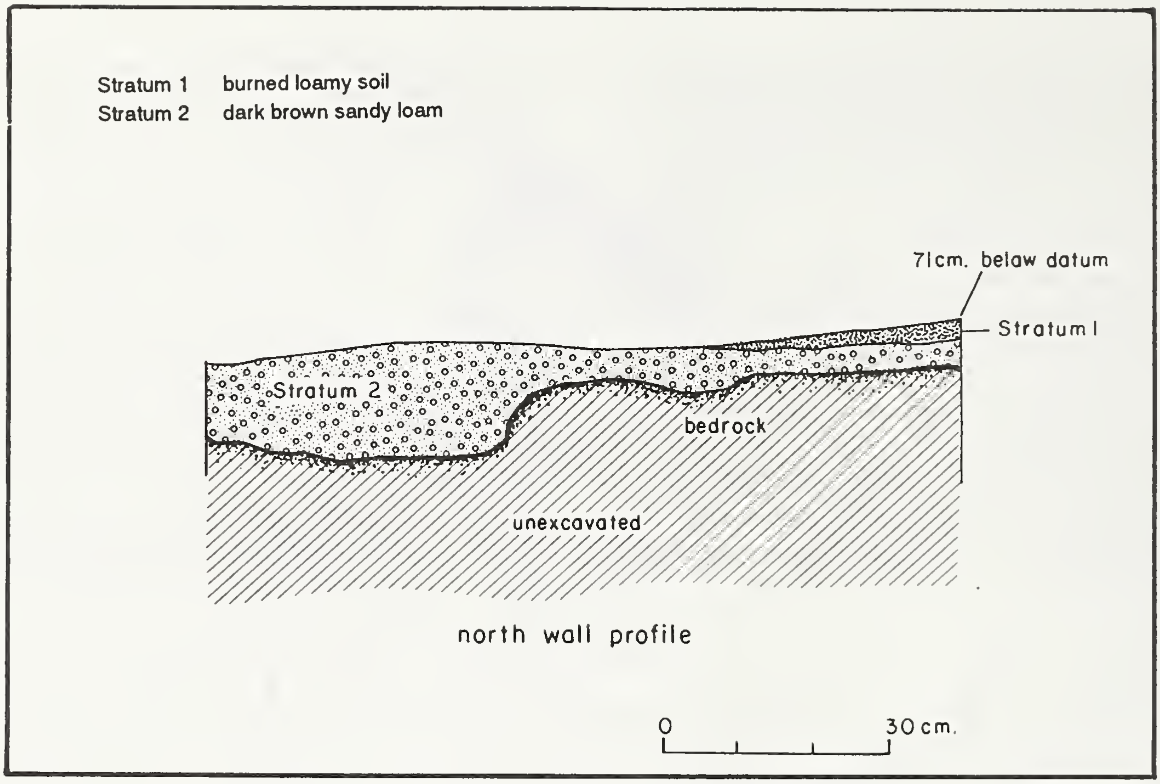

Figure 11—AR-2516, profile of Test Pit 1, north wall.

dark brown sandy loam. The stratum was dominated by deteriorated welded tuff. The number of artifacts decreased sharply in this stratum. Excavation ceased when bedrock was exposed. There was some subsurface burning of roots.

Moderately Burned Sites

Site Number: AR-03-10-03-1905

Burn Intensity.—Moderately burned

Cultural Affiliation.—Anasazi A.D. 1300–1750

Work Performed.—The site was mapped, two samples of surface artifacts were collected from the southeast quadrant, one isolated lithic artifact was collected, field analysis of tuff building blocks was performed, and two test pits were excavated.

Site Description.—AR-1905 consists of the collapsed remains of a small masonry structure and an associated artifact scatter. The site is located on a gentle south-facing slope with a drainage approximately 42 m to the southwest. The collapsed architecture consists of shaped and unshaped tuff blocks. The tuff blocks cover an area 6.8 m north-south by 8.0 m east-west. An extensive artifact scatter exists south of the rubble mound and the heaviest concentration of artifacts is centered in the southeast. Site dimensions, including the entire artifact scatter, are 45 m north-south by 59 m east-west, covering an area of 2,655 sq m (fig. 12).

The site is classified as moderately burned. The fire had visibly altered the condition of the architectural material and the artifacts. The trees were burned to the top with only a few brown pine needles left on the upper branches. Nearly all the duff on the ground surface was burned except for small amounts of charred needles remaining under some trees. The fire had severely spalled 90 percent of the exposed tuff blocks in the rubble mound. Two large burned logs remain on top of the rubble mound and the logs measure 2.7 m and 3.4 m in length. The shadowlike remains of another large burned log, 6-by–1 m, were present on the east side of the masonry structure; everything in the immediate vicinity of this area was charred. Many natural outcroppings of tuff and exposed bedrock in the area were spalled, cracked, or exploded.

A site datum was established with a rebar stake 2 m north of the structure. An arbitrary designation was made for 0.0 elevation of the site and was 10 cm above the ground surface at the site datum. A tem-

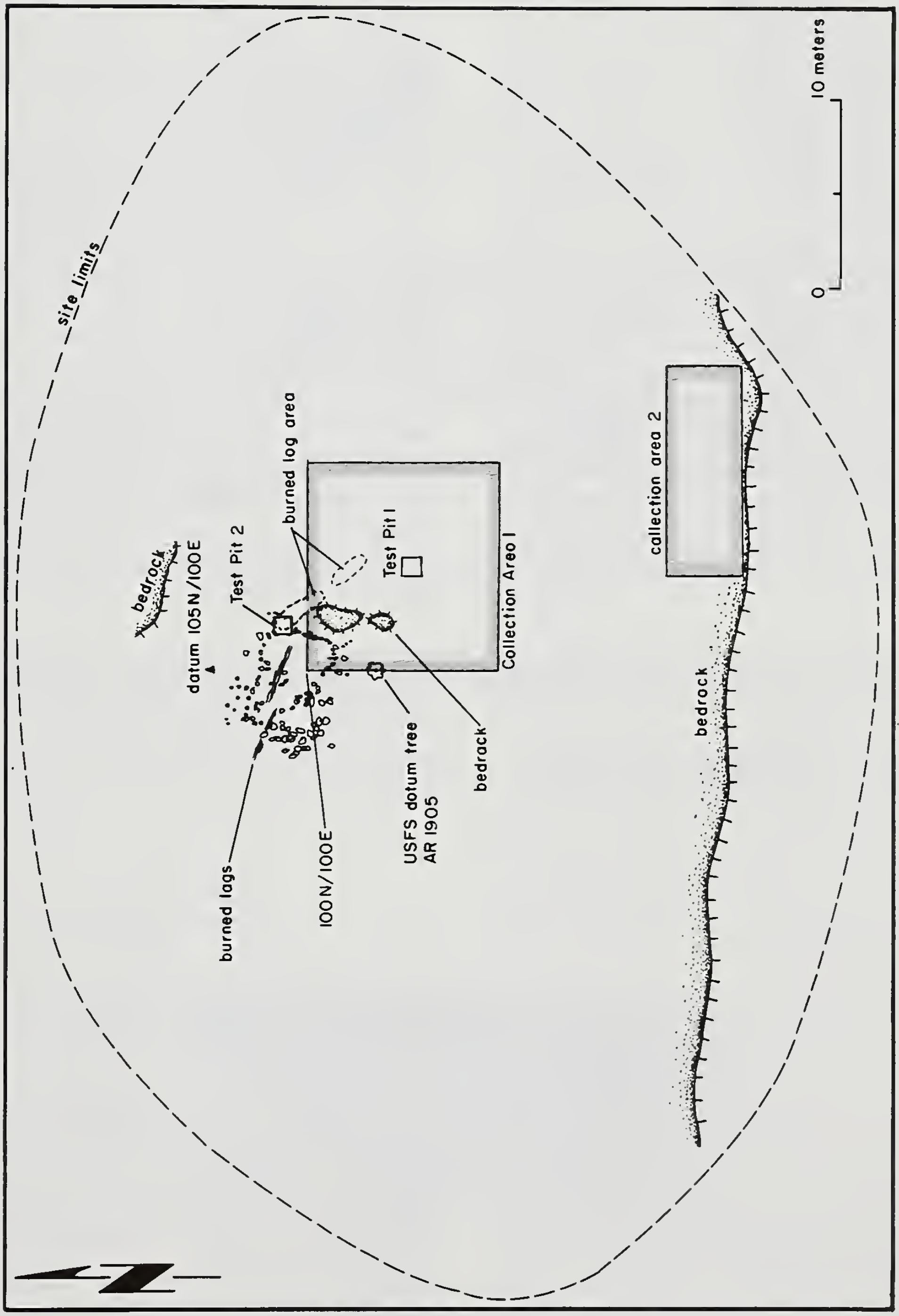

Figure 12—AR-1905, site map.

porary datum (100N/100E) within the rubble area was used to divided the site into quadrants. A grid system was established and a sample of artifacts was collected from within the southeast quadrant. A total of 154 sq m was surface-collected; Collection Area 1 extended from 90N to 100N and 100E to 110E. Collection Area 2 included grids 77N to 80N and 105E to 115E. Two test pits were excavated in order to determine the extent of subsurface fire damage: Test Pit 1 was placed in the center of the artifact concentration in Collection Area 1; Test Pit 2 was placed beneath a burned log and charred area on the collapsed architecture.

Test Pit 1.—Grid 94N/105E was located within the heaviest artifact concentration of the southeast quadrant. Datum for Test Pit 1 was the grid's northeast corner and measures 109 cm below the site datum. Two levels were excavated defining two stratigraphic layers. The only evidence of the Henry Fire was a 2 cm ashy layer of topsoil. Figure 13 is the north wall profile of Test Pit 1; a summary of the stratigraphy follows.

Stratum 1: 10YR4/1, dark gray. Stratum 1 consisted of 2 cm of ash mixed with topsoil and small pieces of spalled and crumbled tuff. Artifacts were recovered from this stratum.

Stratum 2: 10YR4/4, dark yellowish brown. Stratum 2 (16–18 cm thick) was sandy loam with 30 percent tuff gravels and 10 percent small tuff blocks. Artifacts were located 15 cm below ground surface and then ceased. No burning was evident.

Test Pit 2.—Grid 100.8N/101.8E was placed on the collapsed architecture where a log had completely burned leaving only a charred area. The datum for the test pit was in the southwest corner, 30 cm below the site datum. Two levels were excavated to determine the effect of burning caused by the longer residence time of the burned log. Effects of the Henry Fire were evident by the surficial cobbles being blackened, reddened, and more spalled than other areas at the site. Excavation revealed that this area of the structure consisted of wall fall from the northeast corner and possibly interior portions of the structure. The stratigraphy in this test pit was similar to Test Pit 1. Figure 14 is a plan view map showing the subsurface burned areas of the wall fall in Stratum 2; a summary of the stratigraphy follows.

Stratum 1: 10YR4/1, dark gray. This stratum consisted of an ashy topsoil 1–3 cm thick. It contained cobbles, ash and charcoal, deteriorated bedrock, and rootlets. A few artifacts were present in this stratum.

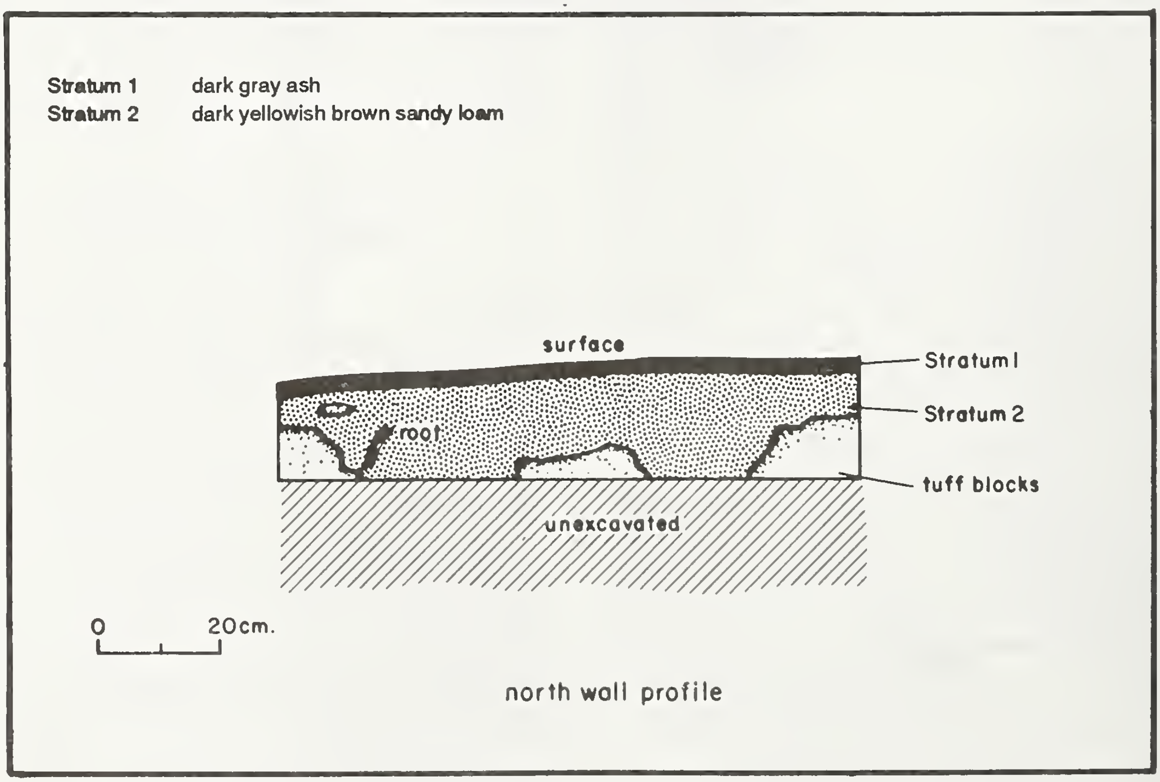

Figure 13—AR-1905, profile of Test Pit 1, north wall.

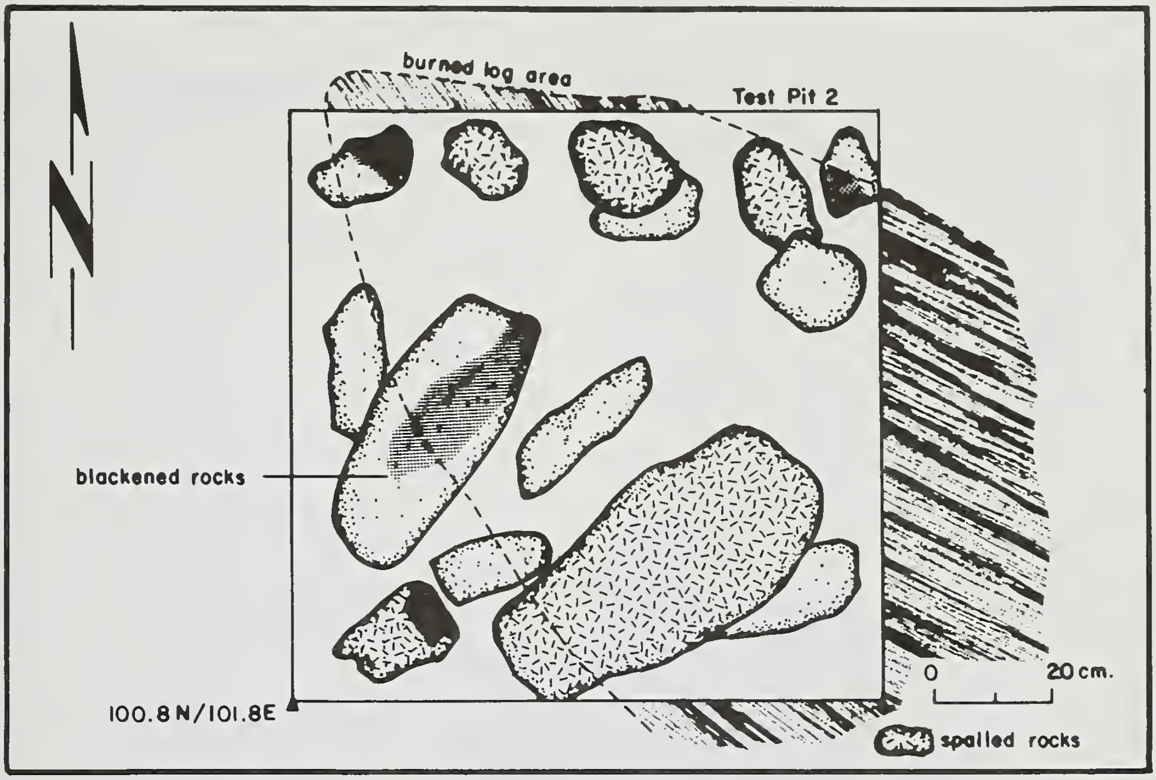

Figure 14—AR-1905, plan of Test Pit 2, base of layer 2.

Stratum 2: 10YR4/4, dark yellowish brown. Stratum 2 was a powdery sand with deteriorated bedrock and some tuff spalls in the matrix. It also contained large cobbles from the collapsed wall and ash and charcoal from the recent burn. No artifacts were located in this stratum.

Site Number: AR-03-10-03-2513

Burn Intensity.—Moderately burned

Cultural Affiliation.—Anasazi A.D. 1300–1750

Work Performed.—The site was mapped, a sample of surface artifacts was collected from the southeast quadrant, field analysis of tuff building blocks was performed, and two test pits were excavated.

Site Description.—AR-2513 consists of a collapsed, small masonry structure and an associated artifact scatter. It is on a west-facing slope that overlooks a south-trending drainage. The artifact scatter consists of ceramic and lithic artifacts and has the highest density of lithic artifacts of all sites in the Henry Fire study. The collapsed masonry covers an area 8.5 m north-south by 8.0 m east-west and the structure is composed of shaped and unshaped tuff blocks. The site dimensions are 67.5 m north-south by 50 m east-west, covering an area of 3,375 sq m (fig. 15). The heaviest concentration of artifacts lies to the southeast of the rubble mound; a lithic reduction area is located northwest of the structure on the slope that extends down into the drainage.

This site was classified as moderately burned. The trees have been burned from 9 to 12 ft (2.74–3.66 m), leaving some needles on the branches. The duff was burned between the trees, exposing a very burned ground surface. At the base of the trees there are still some partly charred needles present, probably because the duff was thicker in these areas. Of the tuff blocks, 100 percent were affected by the fire and these are spalled, exploded, disintegrated, and blackened.

The site datum is marked with a piece of permanent rebar within the masonry structure. An arbitrary designation was made for 0.0 elevation of the site and was 10 cm above the ground surface at the site datum. This point was labeled 100N/100E and was used to divide the site into quadrants and to establish a grid system. A sample of surface artifacts was collected from the southeast quadrant. The collection area extended between 94N to 99N and 100E to 105E (36 sq m). A dense lithic reduction area in the northwest quadrant, between 100N to 107N and 78E to 84E (56 sq m), was also collected. One isolated heat-

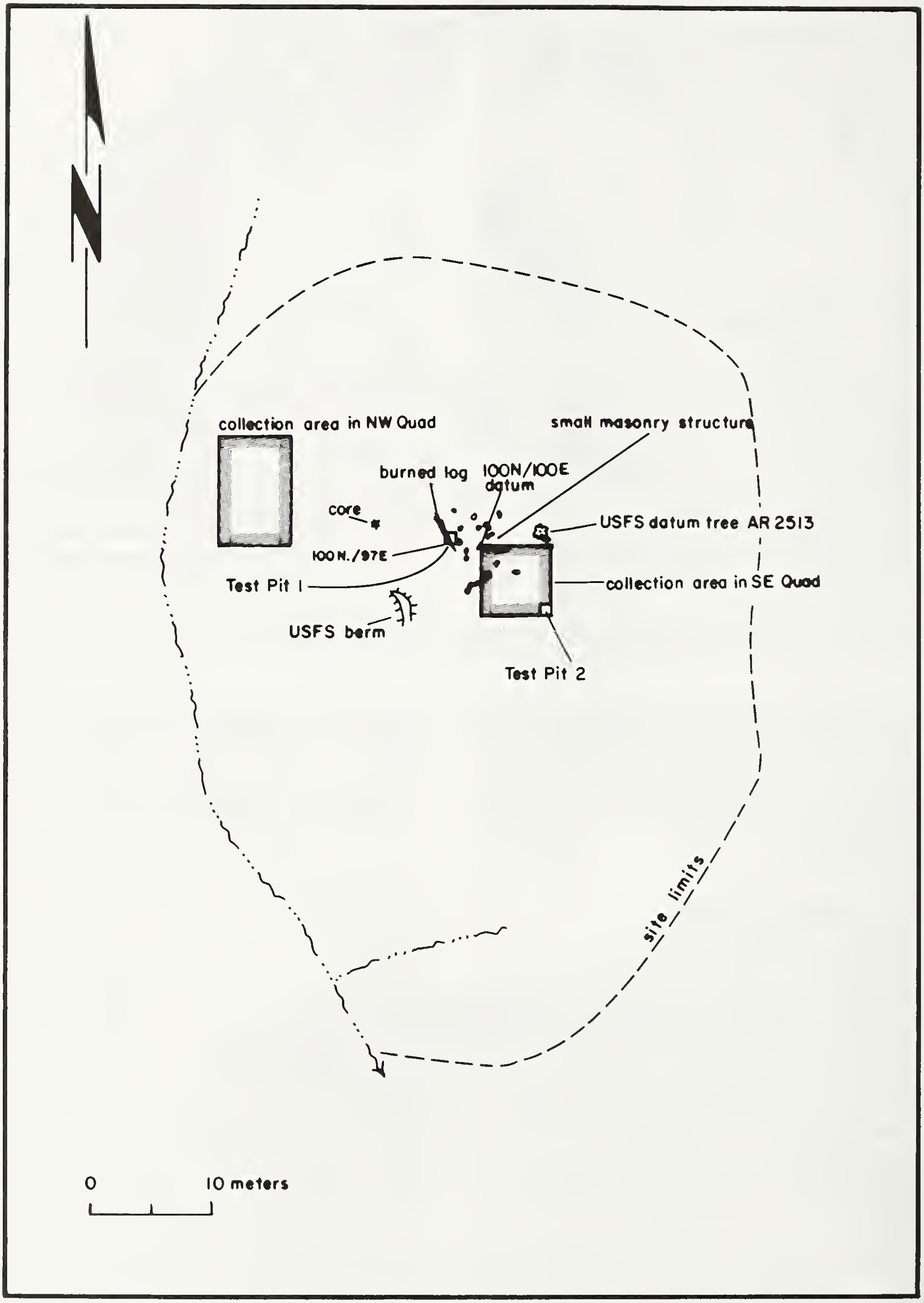

Figure 15—AR-2513, site map.

treated Pedernal chert scraper was collected from 102N/91E. Two test pits were excavated to determine the extent of subsurface fire damage. Test Pit 1 was situated in an area where a log had burned across the northwest portion of the structure. Test Pit 2 was excavated in the densest artifact concentration within the southeast quadrant (fig. 16).

Test Pit 1.—Grid 100N/97E was situated in an intensely burned area where a tree had fallen across the structure and completely burned. This heavily burned area extended across the grid from the south-central portion to the northwest corner of the grid. The humus layer was burned, leaving behind a blackened sandy soil. Branches of the log were imbedded in the ground, resulting in the soil being burned to varying depths (2–10 cm below the present ground surface). It is uncertain if the tree fell while burning or burned on the ground. The east half of this unit exposed wall fall and this was left intact. In the southwest quadrant, under the burned area, is a blackened rock 5 cm below ground surface (fig. 17). Newly fallen needles lightly covered the ground surface. Two stratigraphic levels were defined (fig. 17). Stratigraphy of the profile follows.

Stratum 1: 10YR2/1, black. This 2–4 cm layer of topsoil consisted of a fire-burned black, very fine sandy silt with small gravels of deteriorated tuff. The profile of the west wall only shows burning from 2–4 cm deep; however, in other portions of the test pit, Stratum 1 extended 10 cm below the ground surface. There were nine small tuff stones along the east half of this grid that likely were a portion of the wall fall. Most of the blackened area is in the west half of the grid. Cultural materials were recovered from this stratum.

Stratum 2: 10YR5/3, brown. This stratum is a fine sandy silt with small gravels of tuff (16 cm thick). The tree that fell across the structure lodged branches into the ground. Portions of Stratum 2 have been burned by these branches. Burning extends to a depth of 10 cm below the ground surface (not shown in profile). Cultural materials were present. Specifically, a severely heat-treated pink chert scraper was removed from the blackened soil. It had potlids and spalled areas caused by the intensity of the fire. The spalled-off potlids were found next to the scraper. Figure 16 shows a plan view of the excavated unit with all of the stones that extended into this layer and exhibited blackening from the fire.

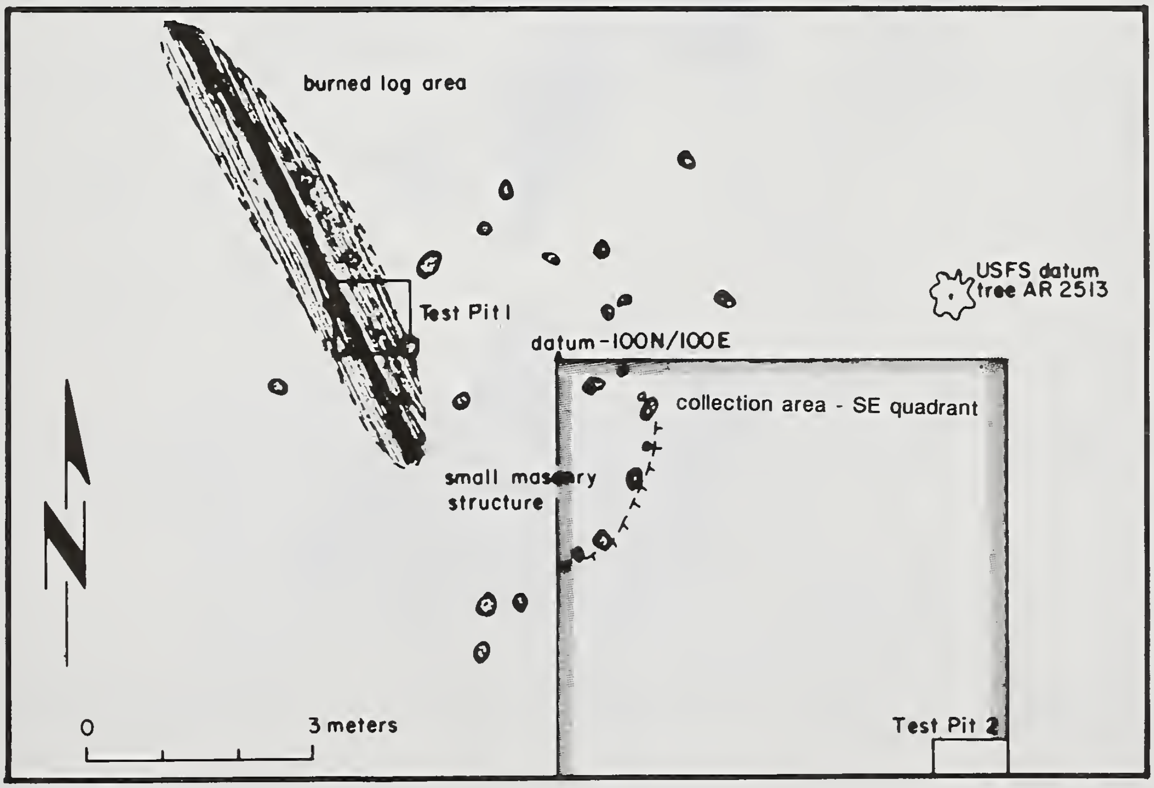

Figure 16—AR-2513, detail of structure and burned log area.

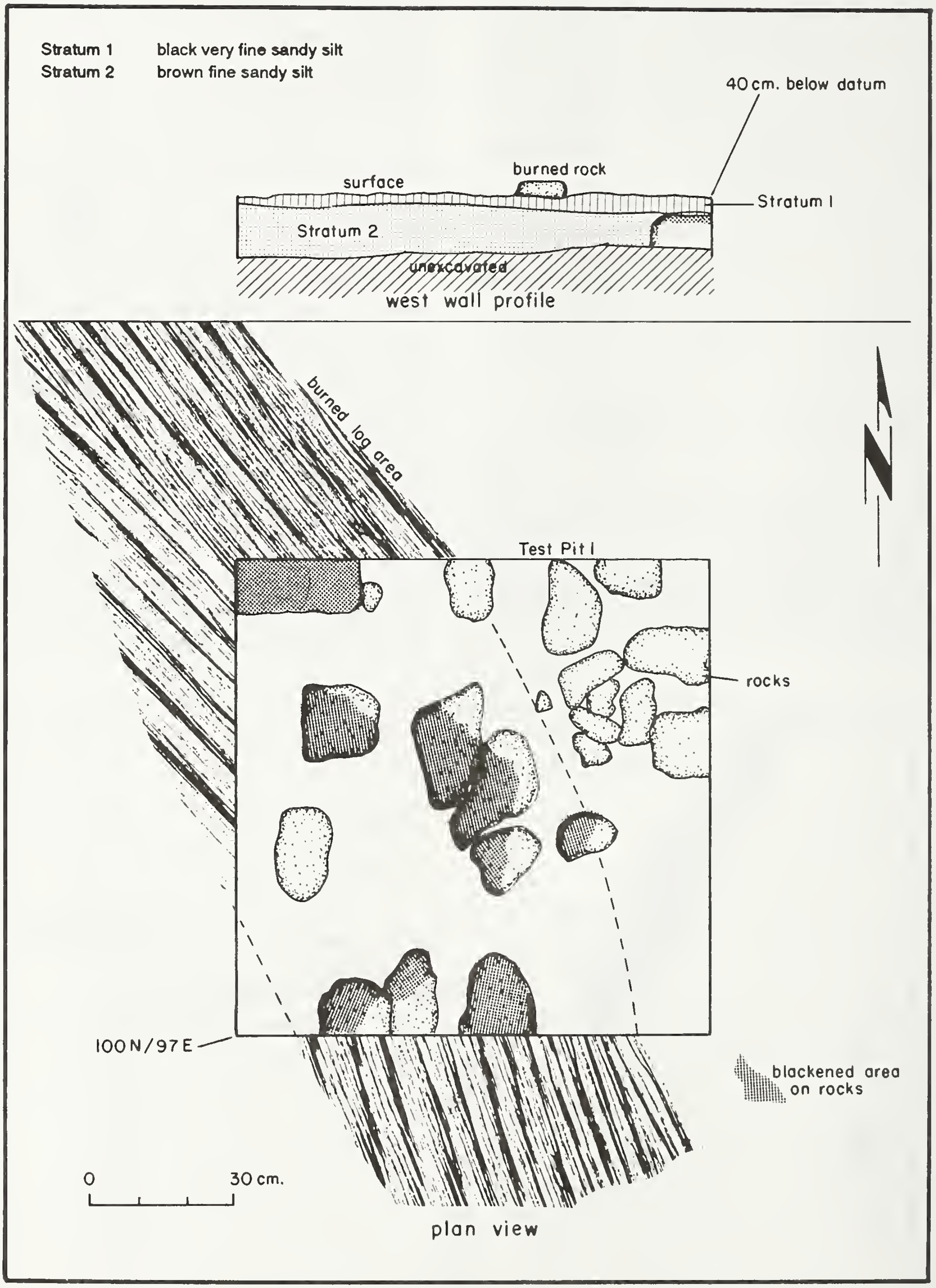

Figure 17—AR-2513, plan and profile of Test Pit 1.

Test Pit 2.—Grid 94N/105E was excavated in a dense artifact concentration (possible midden) within the southeast quadrant. The datum for Test Pit 2 was the northeast corner of the test pit and was 64 cm below the site datum. Effects of the Henry Fire were evident in the top 2 cm of burned and blackened humus. Two strata were defined in this test pit and are illustrated (fig. 18). Descriptions of the stratigraphy follow.

Stratum 1: 10YR2/1, black. The stratum consisted of 2 cm of burned humus mixed with the underlying sand layer. There was a high artifact density towards the surface and most of the items were burned.

Stratum 2: 10YR5/3, brown. The soil was a homogeneous sandy soil (18 cm thick) with a few charcoal flecks. Burning was evident in Stratum 2 but was not a result of the Henry Fire. The first 8 cm of soil was dominated by medium-sized, highly friable cobbles, some of which were burned. These may be deteriorating bedrock or construction elements. Cobbles increased significantly towards the bottom of the pit, and a large piece of bedrock was present in the north wall. A chalcedony projectile point with a reworked notch was recovered from this stratum. A large number of artifacts were found and some were burned. Burning was evident on the bedrock at the bottom and west side of the stratum. This appeared to be from an older burn, possibly culturally related and not the result of a natural forest fire.

Heavily Burned Sites

Site Number: AR-03-10-03-1930

Burn Intensity.—Heavily burned

Cultural Affiliation.—Multicomponent Anasazi A.D. 1250–1350/1300–1750; A.D. 1680–1740

Work Performed.—The site was mapped, a sample of surface artifacts was collected from the southeast quadrant, field analysis of the tuff building blocks was performed, and one test pit was excavated.

Site Description.—AR-1930 consists of two small masonry structures and an extensive ceramic and lithic artifact scatter. The site measures 38 m north-south by 85 m east-west, covering a total of 3,230 sq m (fig. 19). AR-1930 is situated on the southeast slope of a hill. Many artifacts are eroding downslope to the east. Structure A (5-by-4.5 m) is located in the eastern portion of the site and is a single-room structure constructed of shaped and unshaped tuff blocks. The main concentration of artifacts for the site is found east and southeast of this feature. Structure B is 43 m to the

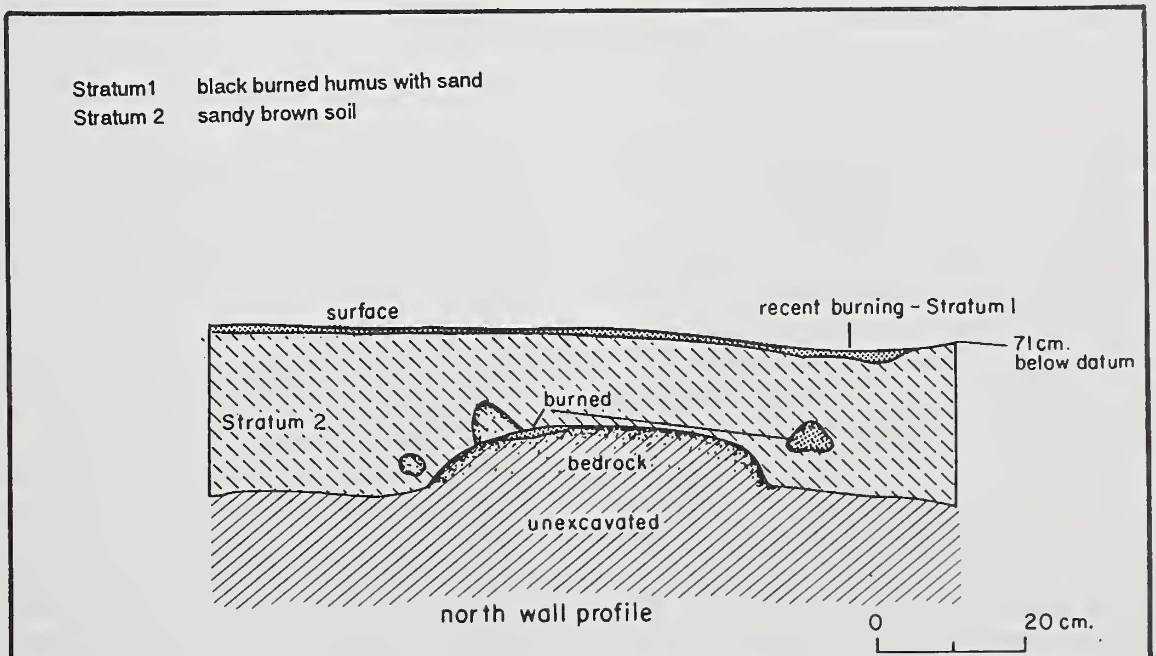

Figure 18—AR-2513, profile of Test Pit 2, north wall.

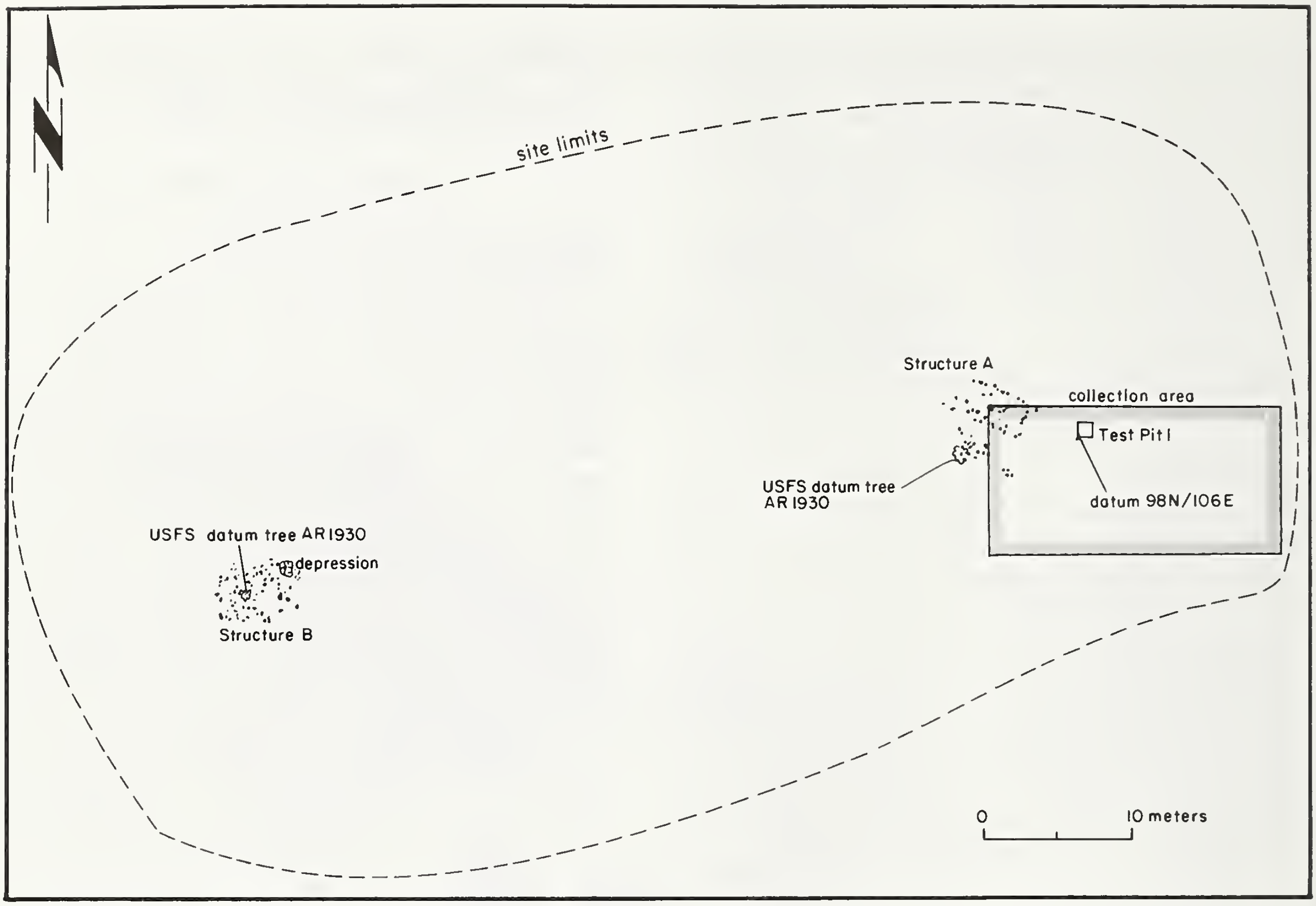

Figure 19—AR-1930, site map.

west of Structure A and measures 4-by-4.5 m. This one-room feature is made from shaped and unshaped tuff blocks and has a light artifact scatter to the east.

The eastern portion of AR-1930 was heavily burned by the Henry Fire while the rest of the site appears to be unburned to slightly burned. Structure A and the associated artifact assemblage have been exposed to a high intensity fire visibly altering the condition of the architectural material and artifacts.

Seventy percent of the tuff building materials of the structure have been affected by the fire. The ponderosa pine trees around this feature are 100 percent burned and blackened with no needles left on the branches. The ground surface is almost completely void of duff and vegetation. A few areas under the trees have patches of burned and blackened duff while the rest of the ground is covered by a very fine-grained, brown sand with patches of light gray ash. The only signs of live vegetation are a few clumps of grass that are beginning to grow back. No BLA was discerned. However, there were several "shadows" to the northeast of Structure A which could represent fallen trees or logs that had been totally consumed in the fire.

Field work was conducted around Structure A to sample the area of high intensity burning. The site was divided into quadrangles around this feature and a grid system was established. 100N/100E is located within Structure A and surface artifacts were collected within the southeast quadrangle of the site. A 200-sq-m area was surface-collected and includes grids 90N to 99N by 120E to 100E. Also collected from the surface were two piece-plotted artifacts (a piece of ground stone and a burned diagnostic glaze ware sherd). Types of artifacts collected included ceramic, lithic, and ground-stone items. The site datum was placed at the southwest corner of grid 98N/106E, which is also the grid designated for Test Pit 1 (fig.

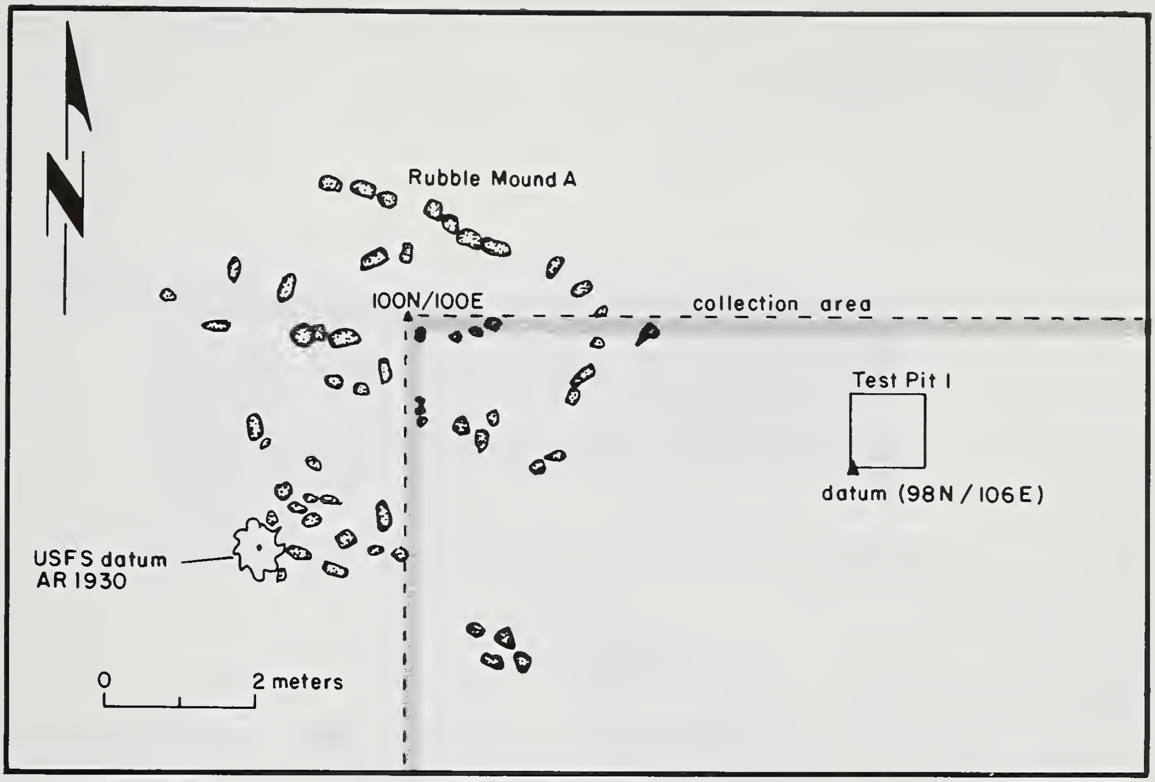

Figure 20—AR-1930, detail of rubble mound A.

20). An arbitrary designation was made for 0.0 elevation of the site and was 10 cm above the ground surface at the site datum.

Test Pit 1.—Grid 98N/106E was placed in the southeast quadrangle to determine the extent of burning below the ground surface. The surface of the excavation unit consisted of a brown sand with areas of gray ash. All the pine needles had been burned away by the Henry Fire. This test pit was excavated in arbitrary 10-cm levels and three stratigraphic layers were defined. Test Pit 1 was located within a midden and artifacts were found at the base of Stratum 3. The effects of the Henry Fire had only altered the first 5 cm of soil; other evidence of burning in Test Pit 1 was cultural and due to the presence of the midden. Figure 21 illustrates the stratigraphic profile of the west wall of Test Pit 1.

Stratum 1: 10YR6/3, pale brown. The only evidence of burning due to the Henry Fire was a light ash that was present in pockets on the surface of this excavation unit. This layer consisted of a pale brown, powdery silt with ash and charcoal specks. It ranged in depth from 2 to 5 cm below the present ground surface and contained cultural material.

Stratum 2: 10YR6/3, pale brown. Stratum 2 is a more compact version of Stratum 1 ranging between 2 and 6 cm thick. This layer did not show evidence of burning from the recent fire. This layer consisted of a pale brown silty soil with charcoal flecks and a few tuff cobbles. Artifacts were found in this level.

Stratum 3: 5YR4/4, reddish brown. Stratum 3 is an organic middenlike layer with burned clay, charcoal flecks, and ash. The burning exhibited here is probably due to the area being utilized as a trash dump where embers and other burned material were discarded. This layer was composed of burned sandy clay with charcoal flecks, some ash, and a few tuff cobbles. The artifact density increased in this stratum.

Site Number: AR-03-10-03-1931

Burn Intensity.—Heavily burned

Cultural Affiliation.—Anasazi A.D. 1300–1750

Work Performed.—The site was mapped, a sample of surface artifacts was collected from the southeast quadrant, isolated lithic and ground-stone artifacts were collected, field analysis of tuff building blocks was performed, and two test pits were excavated.

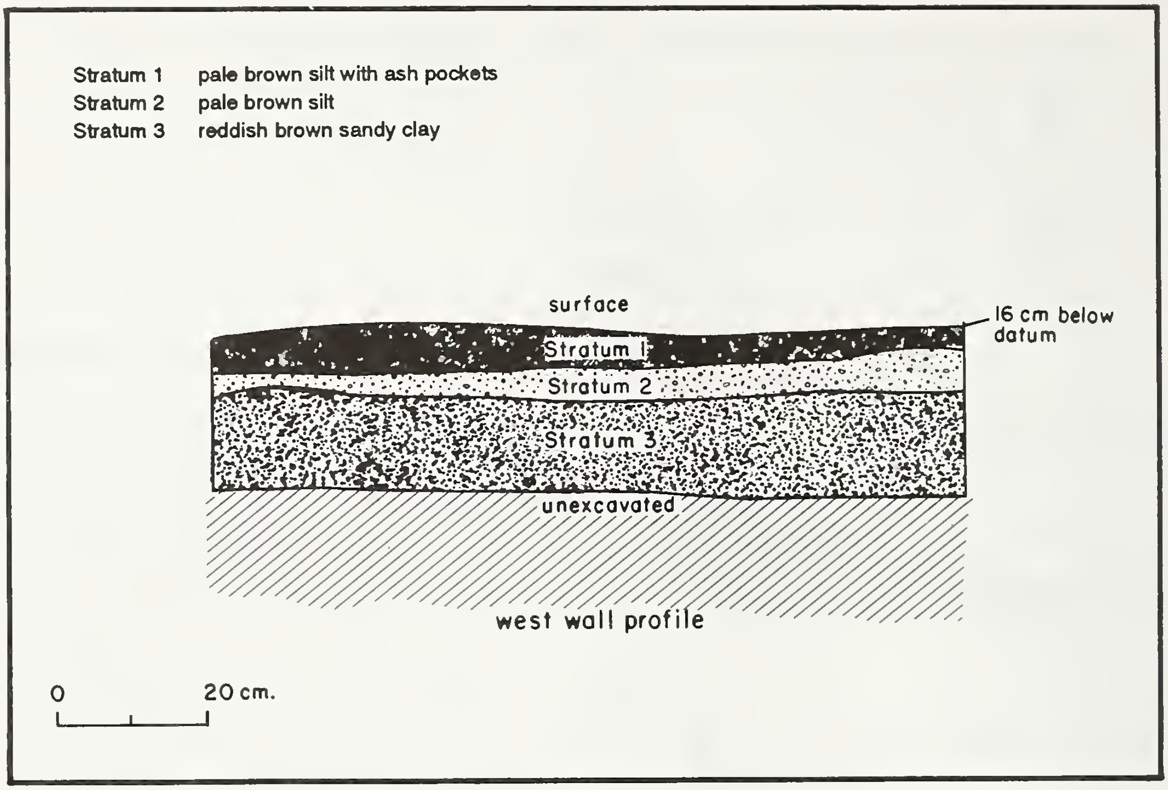

Figure 21—AR-1930, profile of Test Pit 1, west wall.

Site Description.—AR-1931 is a small structural site that consists of a single masonry structure and an associated lithic and ceramic artifact scatter. The site measures 60 m north-south by 76 m east-west, covering a total of 4,560 sq m (fig. 22). AR-1931 is situated on the crest of a low hill and overlooks a moderately steep south-facing slope with outcrops of tuff. The two-room structure is 5-by-4.5 m and is composed of shaped and unshaped tuff elements. Artifacts are scattered around the structural component of the site with the main artifact concentration to the southeast, a possible midden area.

This site was classified as heavily burned. The artifact assemblage and collapsed structural elements of the rubble mound have been altered by the fire. Of the tuff building blocks, 100 percent show evidence of burning. Additionally, the naturally occurring tuff bedrock, downslope of the structure, has been severely spalled due to the intense heat caused by the fire. Some of the sherds found were blackened on the bottom and not on the top, suggesting that soot has weathered away since the fire. A large, highly charred log is located across the northern portion of the structure. The log burned in place and severely blackened the architectural elements. East and southeast of the structure there are other burned logs and branches that lay across the midden area. All of the ponderosa pine trees on the site have been burned 100 percent, the bark and branches were charred, and all the needles were burned away. All of the duff was also burned, leaving behind a blackened and gray ashy soil that covers the present ground surface. The only vegetation present today is a new growth of grass.

Work at the site included dividing the site into quadrants and establishing a grid system. A site datum (permanent rebar) was placed within the masonry structure at 100N/100E; an arbitrary designation was made for 0.0 elevation of the site that was 10 cm above the ground surface at the site datum. A sample of surface artifacts (lithic material and ceramic items) was collected from the southeast quadrant and included grids 94N to 99N and 100E to 109E (54 sq m). Isolated lithic artifacts outside of the collection area were collected by their grid designation. Ground-stone fragments outside of the sample were also collected. Of the two test pits excavated, Test Pit 1 (96N/105E) was placed within the southeast quadrant, and Test Pit 2 (101.5N/97.5E) was located in the structure near the burned log (fig. 23).

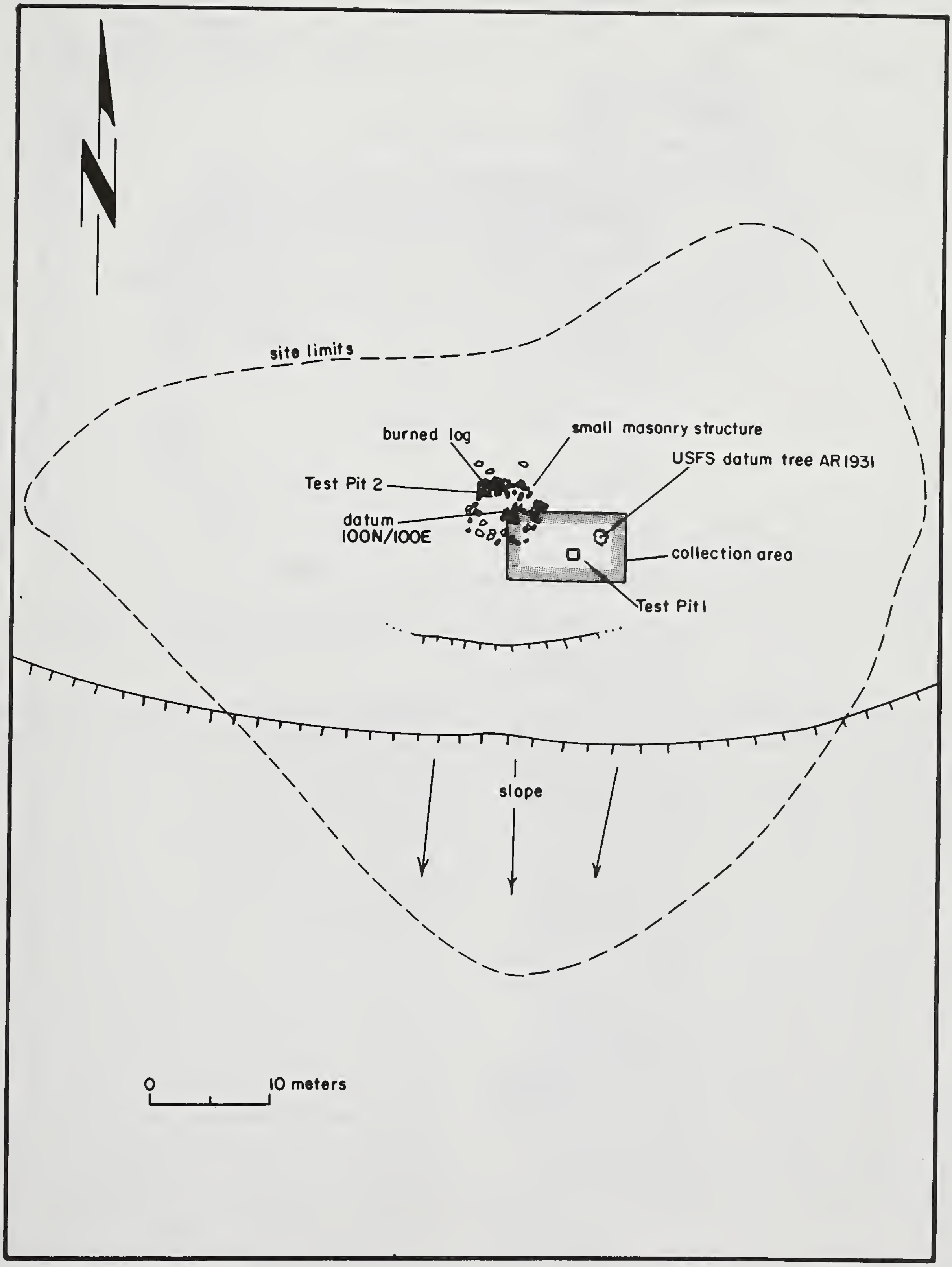

Figure 22—AR-1931, site map.

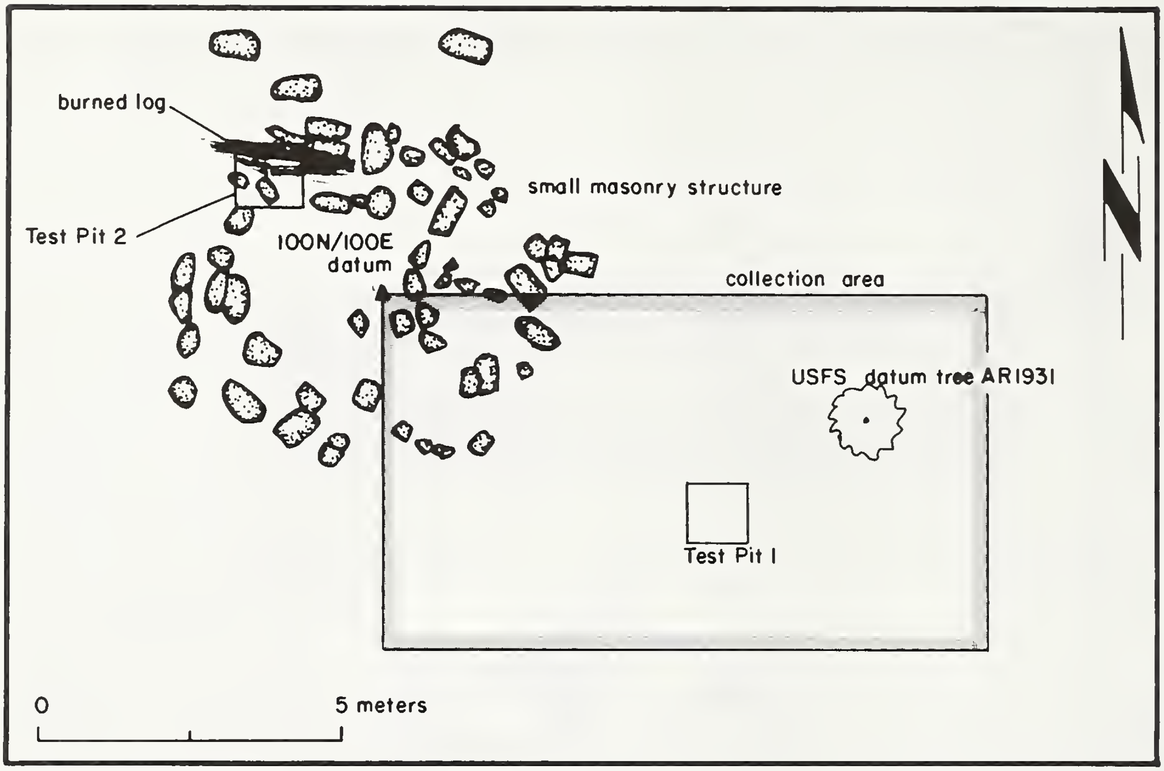

Figure 23—AR-1931, detail of structure and burned log.

Test Pit 1.—Grid 96N/105E was excavated to determine the extent of burning below the ground surface. Datum for this test pit was the main site datum. The surface of the excavation unit was completely void of pine needles and was covered by a gray to black ash. A few clumps of grass were beginning to grow back. Test Pit 1 was dug in arbitrary 10-cm levels. Two 10-cm levels were attempted, but decomposing bedrock and tree roots were encountered 6–8 cm below the ground surface. The only evidence of burning in this test pit was in the first 2 cm of soil (Stratum 1). Figure 24 is the west profile of Test Pit 1 and following is the strata description.

Stratum 1: 10YR2/1, black. Stratum 1 (2 cm thick) was a cultural layer that consisted of an ashy soil and fire-altered artifacts. This was the only layer with artifacts present and some were blackened (soot or adhesions), while others exhibited spalling. Effects of burning from the fire was evident only in the first 2 cm of soil.

Stratum 2: 10YR5/2, grayish brown. This stratum was fine sandy silt with no artifacts or evidence of burning. Stratum 2 was 4–5 cm thick. Unburned roots ran throughout this layer and decomposed rock was encountered.

Stratum 3: 10YR4/2, dark grayish brown. This layer was 12–17 cm thick and was composed of decomposing tuff bedrock and a sandy silt. Tree roots were also present. Stratum 3 was culturally sterile and there was no evidence of burning.

Test Pit 2.—Grid 101.5N/97.5E was placed within the area of the burned log, in the vicinity of the northwest corner of the structure. The datum for this test pit was the main site datum. This excavation unit was excavated to see if the extended residence time of the burning log had an affect on the architectural elements or any other features or artifacts within the structure. Two arbitrary 10-cm levels were dug. When wall fall was encountered it was not disturbed in order to preserve the structural integrity of the masonry feature. Immediately beneath the burned log, the tuff elements were highly blackened and evidence of subsurface burning was apparent in Stratum 1. Descriptions of the stratigraphy are listed below and are shown in the east profile of Test Pit 2 (fig. 25).

Stratum 1: 10YR4/2, dark grayish brown. This layer was a sandy soil that had been burned by the Henry Fire and in particular by a burned log. Stratum 1 extended 2–6 cm down from the present ground surface and consisted of deteriorated tuff

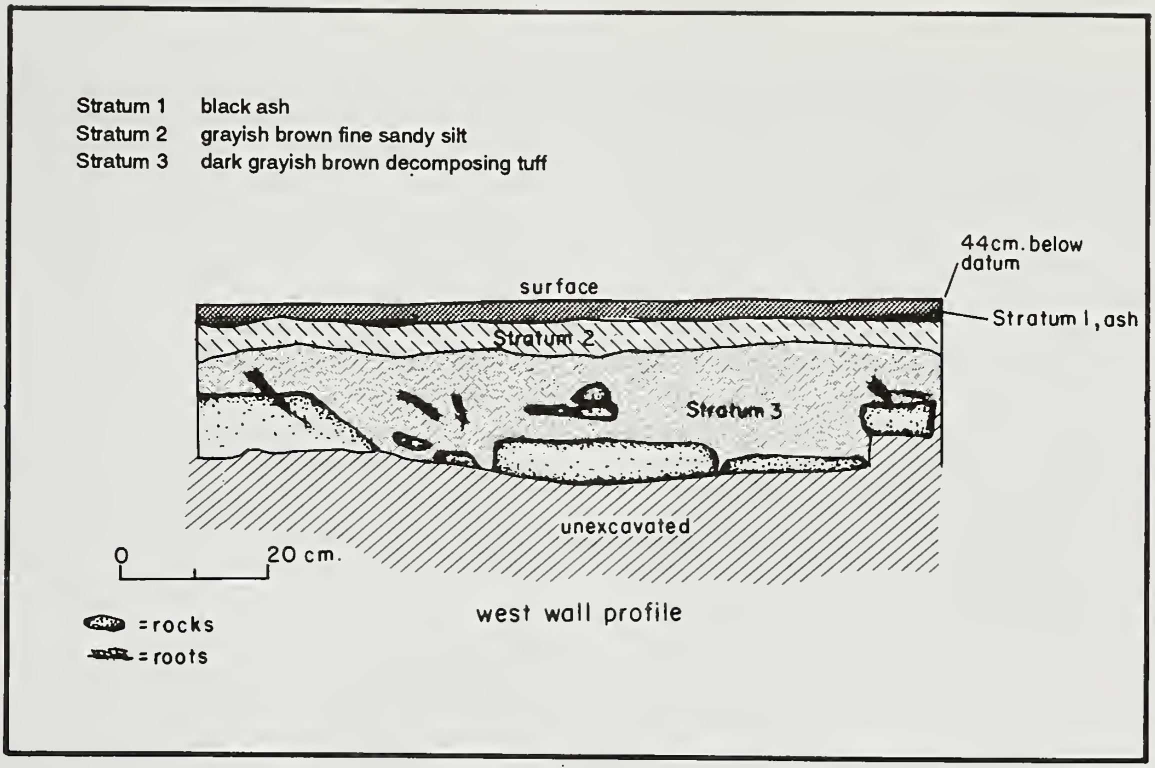

Figure 24—AR-1931, profile of Test Pit 1, west wall.

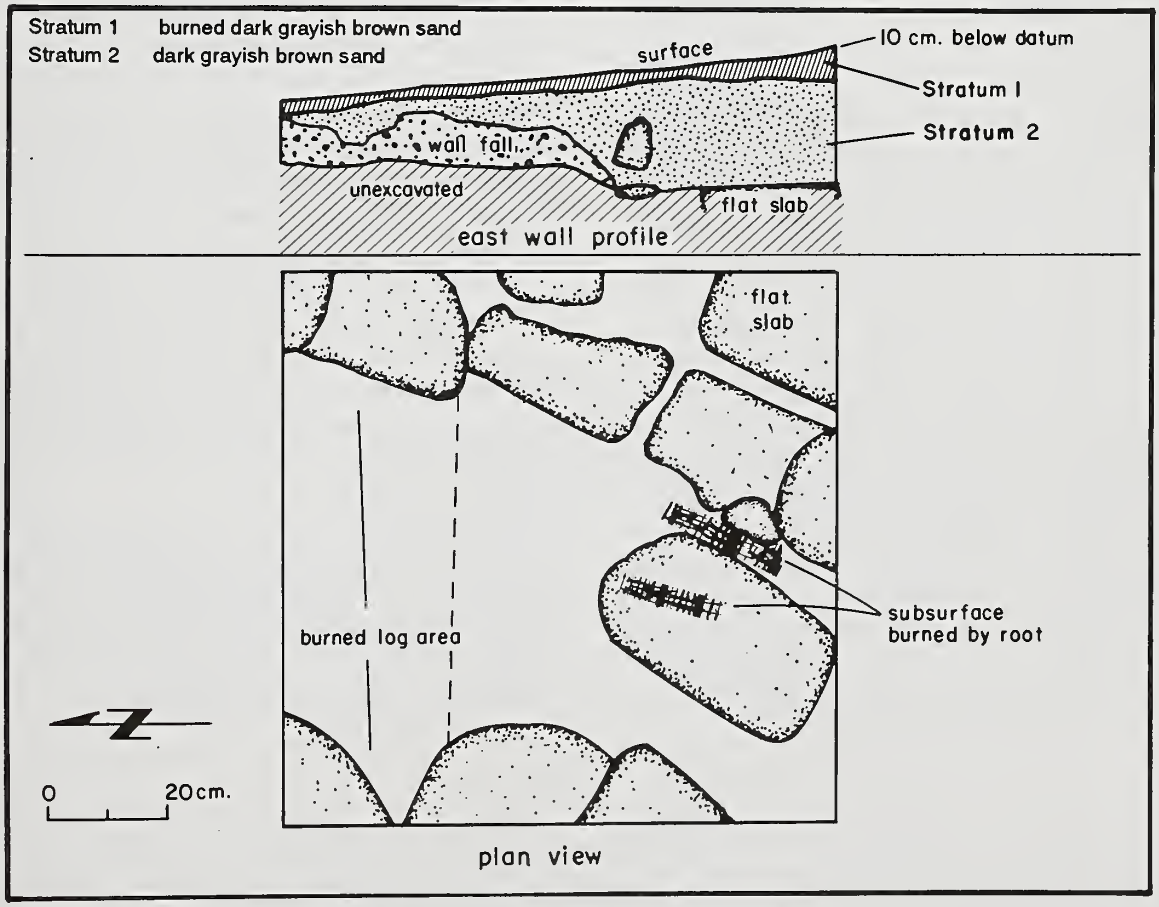

Figure 25—AR-1931, plan and profile of Test Pit 2.

rock, wall fall, burned roots, and charcoal chunks, and flecks. This stratum was heavily burned in the southern half of the grid where burned roots have extended below the ground surface (fig. 25). The only two artifacts found subsurface were located in Stratum 1; they were both sherds that had been fire-altered. One of the sherds was uncovered in the highly burned root area.

Stratum 2: 10YR4/2, dark grayish brown. Stratum 2 was a 2–18 cm thick sandy soil layer with no indication of burning. The wall fall of the structure extends into this layer. Along the lower, eastern side of this stratum, the west wall of the structure was uncovered. This wall alignment was composed of unshaped tuff elements. There was a horizontal slab in the southeast corner of the grid that may represent either a floor or possibly a collapsed wall element (fig. 25).

Control Site

Site Number: AR-03-10-03-1886

Burn Intensity.—None

Cultural Affiliation.—Multicomponent Anasazi A.D. 1300–1750/A.D. 1725–1800

Work Performed.—The site was mapped, a sample of surface artifacts was collected from the southeast quadrant, an isolated ground-stone artifact was collected, field analysis of tuff building blocks was performed, and one test pit was excavated.

Site Description.—Duff covers 90 percent of the ground surface and is especially thick, making visibility of surface artifacts difficult. AR-1886 consists of a small masonry structure situated atop a north-south trending ridge among tuff outcrops. The main artifact scatter is concentrated downslope and to the east and south of the structure. The single-room structure is composed of shaped and unshaped tuff elements and measures 5.5-by-8.6 m. The structure has been disturbed along the west side, and a 1-m-high cairn was constructed with the tuff building blocks. AR-1886 measures 110 m north-south by 59 m east-west and covers a total of 6,490 sq m (fig. 26).

The site was divided into quadrants and a grid system was established from 100N/100E located within the masonry structure. A sample of surface artifacts was collected from the southeast quadrant and includes grids 94N to 99N and 110E to 117E (48 sq m). The duff in these grids had to be removed in order to obtain better visibility of the surface artifacts; a higher number of artifacts was collected than was originally thought to be present. One isolated, blackened hammerstone was collected outside of the collection unit, within grid 102N/108E; this is the only fire-altered artifact present at the site and it may have been affected by fire because of previous forest fires or a cultural alteration to the artifact. Test Pit 1 was placed within the surface collection area, in the area of highest artifact density. The datum for this site is located at the southwest corner of the test pit and 0.0 m elevation for this site was 10 cm above the ground surface. A piece of rebar was left to permanently mark the site datum. Ten percent of the tuff building blocks exhibit natural erosion, such as deterioration and very light spalling. Lichen was growing on 90 percent of the tuff elements (fig. 27).

Test Pit 1.—Grid 95N/112E was located downslope and to the southeast of the masonry structure. It was placed within the southeast quadrant in the surface-collected area. Two arbitrary 10-cm levels were dug and two stratigraphic layers were defined. No subsurface burning was noted in this excavation unit. Figure 28 shows the west profile of the test pit and following is the stratigraphic description.

Stratum 1: 10YR4/3, brown/dark brown. This layer was a humus layer that consisted of decomposing pine needles with an underlying loamy sand. Stratum 1 was 4–9 cm thick and contained pockets of sand and a few tuff rocks and gravels. This was a cultural layer that contained ceramic artifacts. No burning was noted.

Stratum 2: 10YR3/3, dark brown. Stratum 2 was a more compact loamy sand with ash and tuff pebbles in its matrix. The artifact density increased (N = 52) in this layer suggesting that this test pit was located within a midden. The stratum was 6–20 cm thick. No charcoal or burning was present.

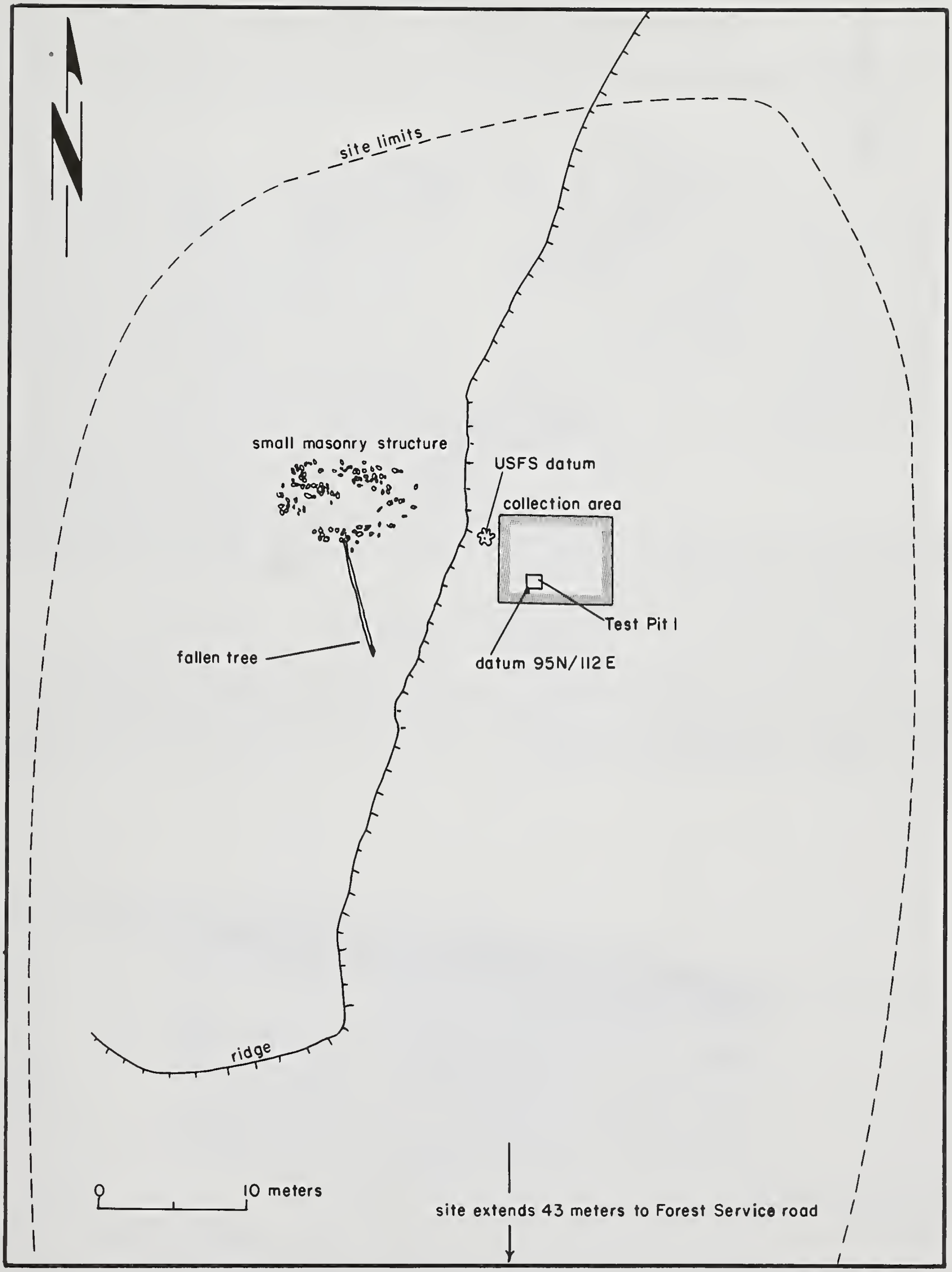

Figure 26—AR-1886, site map.

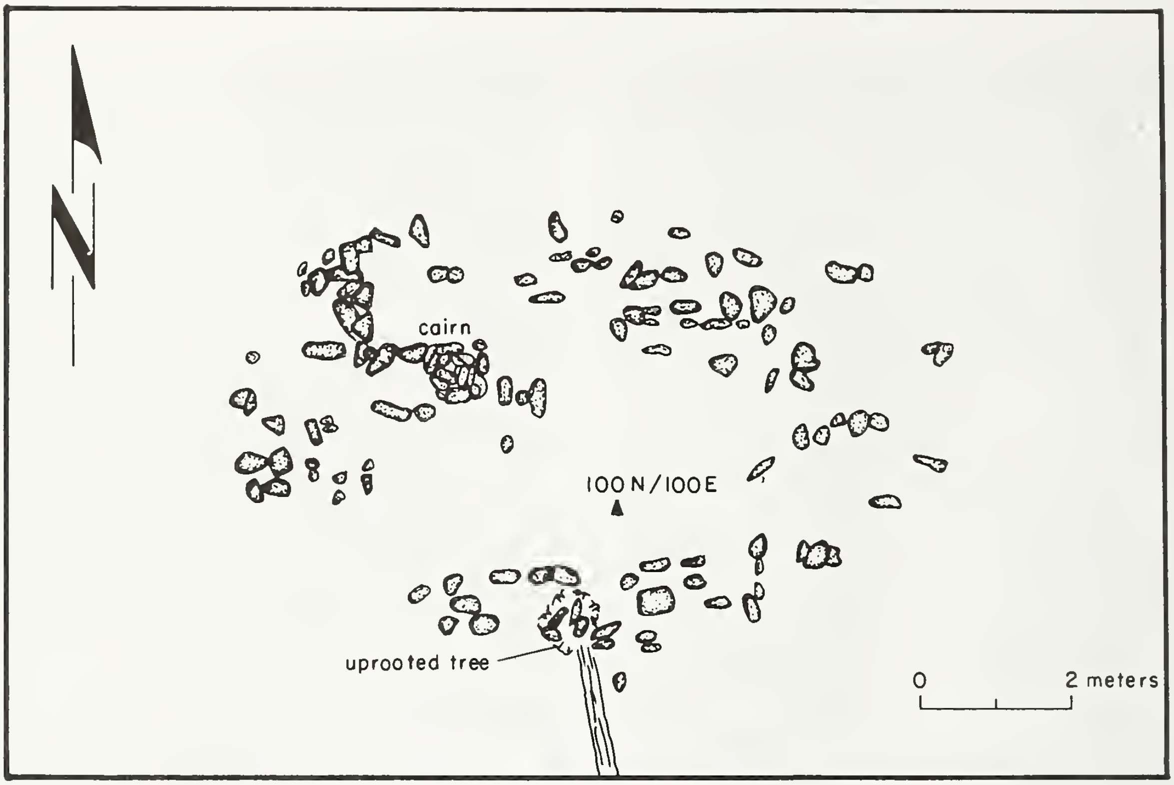

Figure 27—AR-1886, detail of structure.

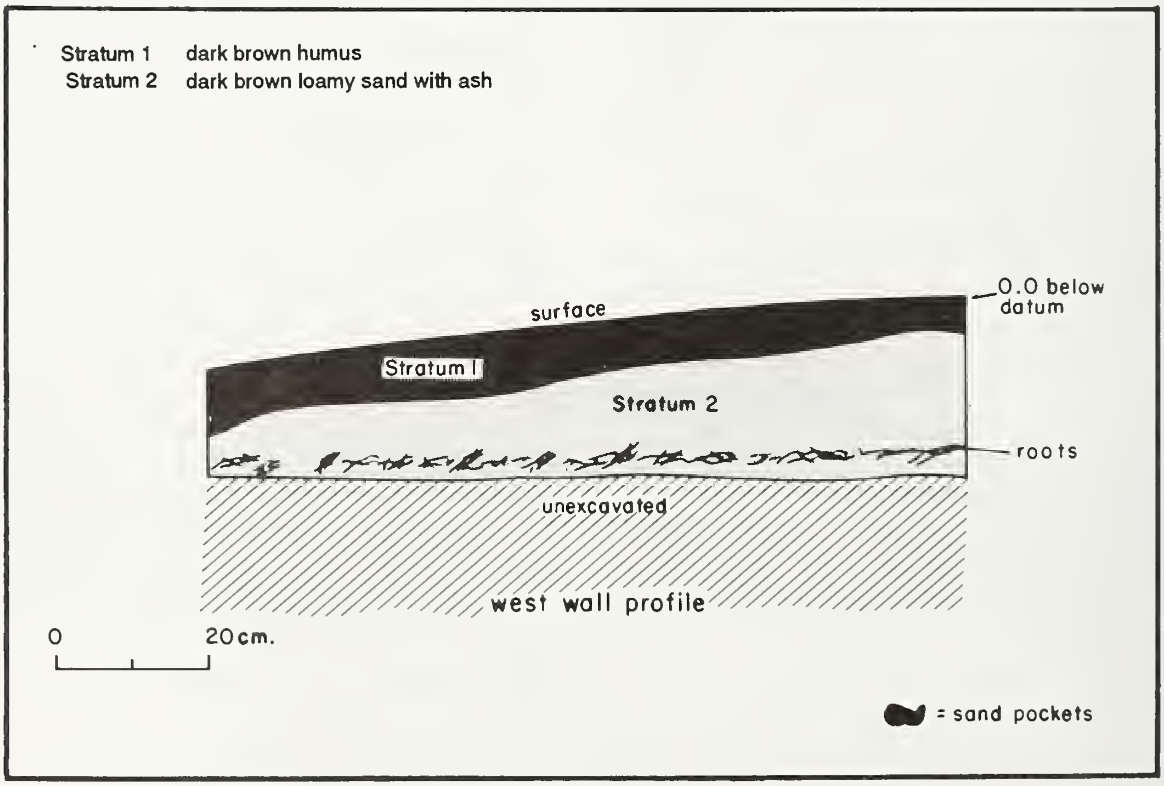

Figure 28—AR-1886, profile of Test Pit 1, west wall.

CERAMIC ARTIFACT ANALYSIS

Joan K. Gaunt and Stephen C. Lentz, Office of Archaeological Studies

A total of 834 sherds from 6 burned sites were analyzed during the laboratory phase of the project. An additional 170 ceramic artifacts were also analyzed from the unburned controlled site. The objective of the analysis was to monitor the effects of fire on a sample of ceramic artifacts. The artifacts were recovered from surface collections of the site middens (usually the southeast quadrant) and test excavations. Ceramics were present on sites in the low, moderate, and high burn categories, and on the unburned control site. No fire effects were observed on ceramic artifacts at the control site. The OAS and the USFS developed a sampling strategy for sites with a high number of artifacts that allowed a limit of approximately 200 artifacts be analyzed in the field.

Methods

Two analyses were carried out. A routine ceramic analysis was conducted to record information on the archaeological characteristics of the assemblage, and a specialized analysis was designed to record effects judged to have been created by fire.

Archaeological Analysis

Taxonomic data (as defined by standardized OAS ceramic analysis methods; draft copy on file, OAS) were monitored. These data include ceramic type, vessel form, paste color, texture, thickness, and temper group. The sherds were not washed or numbered prior to analysis to preserve the variables needed to determine fire effects. Petrographic attributes of all sherds were examined under a 40X microscope. The typological/functional attributes were used to group the sherds by pottery type (table 6).

Fire Effects Analysis

In the absence of knowledge of the condition of the artifacts prior to the Henry Fire, rigorous criteria could not be developed for the specialized analysis. Therefore, all criteria used in this category are subjective.

Four main variables were isolated as contributing to observable fire effects on artifacts. These were initial firing of the ceramic, routine use (cooking pots), past fires (an estimated average of one wildfire every 5 to 7 years, possibly up to 100 fires since the

Table 6—Pottery types identified during the Henry Fire study.

Type	Date	Description
Jemez B/w	1300–1750	Slipped, polished interior and exterior; carbon paint has a tendency to turn brown or red; crystal pumice temper, sometimes vitric tuff in a dark gray clay; Mera 1935, Warren 1979, Oppelt 1988
Vallecitos B/w	1250–1300	Poorly finished slip resembling Santa Fe B/w; with crystal pumice temper; Mera 1935, Elliott 1988
Tewa (Ogapoge?) Polychrome	1720–1800	Carinated bowls, ollas; carbon paint; may have red matte designs; vitric tuff, crystal pumice temper; Mera 1939, Warren 1979, Harlow 1973
Puname Polychrome	1680–1740	Carinated bowls, matte red, black mineral paint; basalt, crystal pumice temper; basalt temper may protrude above surface; Warren 1979, Harlow 1973
Tewa Black	1720–present	Smudged slipped polished black interior bowl; tuff, crystal pumice, scoria temper; Mera 1939
Jemez Utility	1250–1750	Slipped on interior, exterior or both; sometimes lightly polished; surface gray or brown; crystal pumice; vitric tuff, scoria, medium textured paste; Mera 1935

fourteenth century), and the Henry Fire. Since it was not always possible to distinguish one type of burning from the another, monitoring and recording were conservative.

The terms "fire effects" and "damage" are not synonymous. A "fire effect" was a subjective evaluation of effects caused by past or recent fire(s) on an artifact. It may or may not constitute permanent damage to that artifact, and may or may not obscure the diagnostic capabilities of that artifact.

Fire intensities were hierarchically ordered according to light, moderate, and heavy burning; and percentage of surface area altered (for the sooting, spalling, and oxidation categories).

Only attributes subjectively judged to be recent fire effects were coded during the specialized analysis. Variables monitored to study the effects of fire on ceramic items include:

Portion.—This is the part of the item affected by fire. It was estimated in percentages (0 percent, 1–25 percent, 26–50 percent, 51–75 percent, 76–100 percent) for the whole item.

Sooting.—Sooting was defined as the quantity of carbonized particles clinging to the surface of the item. Sooting was attributed to the Henry Fire if the soot was loosely adhering to the surface of the item and could be easily removed, similar to soot on the interior of a stovepipe. This variable was coded incrementally in percentages. Heavy sooting was defined as carbonized particles that would not easily rub off, and that left a stain on the artifact. It was assumed that heavy sooting was the result of repeated sooting episodes from numerous burns, or a combination of past and recent sooting.

Spalling.—This term was adapted from lithic artifact methodology, used for heat-treated artifacts. Spalling was defined as a portion of the surface of the sherd (usually the slip) forcibly detached by heat.

Oxidation.—In the definition used during the analysis, oxidation is color alteration on the exterior of the item due to fire (usually reddening). If the item was highly scorched, there might be a deep blackish red color. It was not determined whether blackening was due to severe oxidation, sooting, or a combination of both of these effects.

Pigment.—This attribute was coded as alteration to the pigment on a painted sherd. These alterations included crackled, vitrified, vaporized (burned off), and color-altered (color changed from original value).

Other Physical Alteration.—These variables included vitrification, adhesions, and crackling. Vitrification was defined as a glassy, glossy quality to the surface of the sherd, accompanied by an overall brittleness. Adhesions are a sticky black substance of unknown origin, probably organic. A slip exhibiting crackling had fine asymmetrical fissures that gave the surface of the sherd a crazed appearance.

Analysis Results

All analyzed items were fragmentary, and no whole vessels were recovered during the study. There were 1,004 items. The following section presents the results of the standard typological/functional ceramic analysis, followed by the observed fire effects (specialized analysis), and a discussion on the entire assemblage and a site-by-site evaluation. The sites are seriated based on the presence of diagnostic ceramic types. Tables 7–12 contain summary information on ceramics by site.

Archaeological Analysis

Pottery Type.—The dominant pottery type recovered from the tested sites was Jemez Utility. A total of 401 sherds (39.9 percent of the total) were from this category. Jemez Black-on-white numbered 179 items, and accounted for 17.8 percent of the total.

Vessel Form.—Half of the assemblage was composed of jar body sherds (N = 504, 50.2 percent). The second most frequent vessel form was bowl body (N = 371, 37.0 percent).

Paste Color, Texture.—The dominant paste color was gray (N = 524, 52.2 percent), followed by half gray, half buff/tan (N = 201, 20 percent). Paste texture was primarily medium-grained (N = 800, 79.7 percent).

Site Chronology.—Grouping the pottery types into discrete classes (table 6) can be used to infer periods of occupation for the sites in the sample.

Sites in the USFS sample were temporally seriated according to the frequencies of diagnostic pottery types. There may be inherent difficulties in the dating of some of the principal pottery types recovered during testing. Jemez Black-on-white may have too broad a signature, and Vallecitos Black-on-white, whose period of use is given as 50 years, may be too narrow. Moreover, based on the temper attributes and design styles, the assumption that Vallecitos Black-on-white originated in the Gallina area, was in use for only 50 years, and was abandoned in favor of Jemez Black-on-white, as Hawley (1936), Mera (1939), and others have suggested, is problematic. Elliott (1988:9–11), based on the excavations of a series of

small structural sites in the Jemez Mountains, has attempted to test Mera's (1939) hypothesis of an early (Vallecitos Black-on-white) and later (Jemez Black-on-white) type within the Jemez pottery series, but his results were inconclusive. Given the small size of the current USFS sample, and the lack of well-dated sites, no attempt will be made to redefine the existing dates for these types. Further excavation and chronometric data are needed to accurately evaluate the existing chronological framework.

The majority of the sites date to the Jemez Black-on-white period (A.D. 1300–1750). Three sites, however, suggest a post-Pueblo Revolt (Refugee) component. The sites and suggested occupation intervals are listed below:

AR-1961: Multicomponent (?), A.D. 1300–1750/1680–1740
AR-2516: A.D. 1300–1750
AR-1905: A.D. 1300–1750
AR-2513: A.D. 1300–1750
AR-1930: Multicomponent, A.D. 1250–1350/1300–1750/1680–1740
AR-1931: A.D. 1300–1750
AR-1886: Multicomponent, A.D. 1300–1750/1725–1800

The chronological implications of the pottery signatures vary. AR-2516, AR-1905, AR-2513, and AR-1931 have an abundance of Jemez Black-on-white and Jemez Utility, and may be associated with the large Pueblo IV sites of Kwastiyukwa and Site 7 on Holiday Mesa. It is possible that AR-1961 is a late site, dating to the latter part of the seventeenth century or early in the eighteenth century. Since there is only a 60-year "window" where two pottery types (Jemez Black-on-white and Puname Polychrome) could have overlapped, it is more likely that the site has a multicomponent occupation, dating to Protohistoric and Historic times. AR-1886, the unburned control site, may have sustained multiple occupations, beginning in the fourteenth century and ending with a Refugee-phase component marked by the presence of the Tewa manufactured polychrome vessel (Ogapoge Polychrome) and Historic Tewa red and brown wares.

Although the Pajarito Plateau has been referred to as the Biscuit Ware Province (Mera 1939), not a single Biscuit Ware sherd was recovered. The small sample of materials from this project may not be sufficient to make any substantive inferences about local pottery manufacture. There may be an indication, however, that ceramic production in this area of the Jemez Mountains is confined to local wares.

Fire Effects Analysis

Fire effects were monitored on ceramic artifacts on all sites except AR-1886. AR-1886 was the unburned control site. Although one artifact (a hammerstone) on this site showed some evidence of burning, it was determined that these effects were not caused by the 1991 Henry Fire.

As mentioned in the disclaimer in the methods section above, attributes monitored during the specialized analysis were (by necessity) subjective. This led to very conservative estimates of effects. The values given below are calculated on an assemblage basis.

Portion Affected by Fire.—A total of 407 artifacts (40.5 percent) exhibited some degree of burning, suggested by Portion Affected by Fire category. The percentage of the surface area of the sherd most affected by fire was 26–50 percent (N = 141), followed by 76–100 percent (N = 127).

Sooting.—Sooting (defined as recent sooting from the Henry Fire) was recorded on 23.2 percent of the assemblage (N = 233). Light sooting was present on 59 items (over 76–100 percent of the total surface).

Spalling.—9.5 percent of the sherds exhibited some evidence of spalling. The most pronounced instances of spalling were found to occur in the high fire effects category (N=22), covering 26–50 percent of the item, followed by light spalling covering 26–50 percent of the item.

Oxidation.—Light oxidation covering 26–50 percent of the surface of the sherd was present on 3.1 percent of the assemblage (N = 31), followed by medium oxidation covering 26–50 percent of the surface on 2.1 percent of the sample (N = 21).

Pigment.—Modification of the pigment of painted sherds was recorded for a small number of the ceramic artifacts (N = 18, 1.8 percent). This was evident primarily in the color-altered category (N = 13, 1.3 percent of total). Some vitrification and some oxidation of the pigment was also noted.

Other Physical Alteration.—Fire effects other than those recorded for the above categories were monitored on 119 sherds (11.9 percent). This category was dominated by adhesions (N = 73, 7.3 percent) and crackled slip (N = 28, 2.8 percent).

Discussion.—The assemblage-based analysis shows that 40 percent of the ceramic artifacts recovered from

burned sites were fire-altered to some extent. Frequently, thermal alteration was present over the entire surface of the item. Low frequencies of sooting were recorded. This might be the result of conservative estimates of this category due to the difficulty in discriminating between sooting from past processes and the Henry Fire. Also, a year has elapsed since the fire, and sooting may have been weathered on the exposed sherds.

Fire Effects by Provenience

Fire effects were evaluated by the varying degree of fire effects upon all surface and excavated ceramic artifacts. This evaluation was conducted for each site type: light, moderate, and heavy fire intensity.

AR-1961 (Light).—On this site, 18 sherds (22 percent) were affected by fire. None of the subsurface artifacts from the single test pit showed any fire effects. Eleven of 18 artifacts showed fire effects in the 76–100 percent category (table 7). There were light to medium proportions of sooting (N = 10, 12.2 percent) and spalling (N = 6, 7.3 percent). Figure 29a exhibits crazing and sooting on a white ware sherd.

AR-2516 (Light).—The total number of artifacts affected by fire at this site was 37 (34.3 percent of the total assemblage) (table 8). All fire effects were recorded on surface artifacts. Twenty-six artifacts were recovered from both levels of Test Pit 1, but no fire effects were recorded on any of the subsurface artifacts. Light to medium sooting was present on 21 artifacts (19.4 percent). Some light spalling was visible on three sherds (2.8 percent); some light and medium oxidation was also present (N = 17, 15.7 percent).

AR-1905 (Moderate).—Fire effects were recorded on 87 (43.1 percent) artifacts (table 9). There were no fire effects recorded on the 34 artifacts recovered from the two test pits excavated at this site. Light to heavy sooting was recorded on 80 artifacts (39.6 percent), with 37 (18.3 percent) had light sooting covering 76–100 percent of the surface of the sherd. Adhesions were present on 6 (3.0 percent) of the artifacts.

AR-2513 (Moderate).—Fire effects were recorded on 75 (67 percent) of the ceramic artifacts, including 6 subsurface artifacts from the total of 18 artifacts recovered from Test Pits 1 and 2 (table 10). There were no ceramic artifacts recovered from Stratum 1 of Test Pit 1, therefore, there is not a column for that provenience in the table. One artifact from Test Pit 1, Stratum 2, had high spalling over one-quarter of its surface. Three artifacts from Test Pit 2, Stratum 2, exhibited medium spalling, medium oxidation, and light sooting over more than half of the total surfaces. A Jemez Black-on-white sherd from Test Pit 2, Stratum 2, exhibited color-altered pigment and a crackled slip due to burning. Of the 94 (83.9 percent of total) artifacts recovered from the surface, 69 (73.4 percent of surface artifacts) showed alteration from fire: sooting (N = 36, 38.3 percent), spalling (N = 19, 20.2 percent), and oxidation (N = 19, 20.2 percent). Figure 29b exhibits medium sooting on a Jemez Utility sherd and fig. 29c shows adhesions present on a white ware sherd.

AR-1930 (Heavy).—Of 204 ceramic artifacts recovered from AR-1930, 111 (54.4 percent) exhibited fire effects (table 11). There was no evidence of burning on the 16 subsurface artifacts recovered from Test Pits 1 and 2. A light to heavy amount of sooting was recorded on 50 artifacts (26.6 percent of the surface artifacts). Other fire effects include light to high oxidation, and light to high spalling. Five items displayed color-altered pigment, and warped and crackled slips were noted. Figure 29d shows a ceramic artifact with heavy spalling and crackling. A high frequency of adhesions were noted (fig. 30b): 41 sherds had adhesions, and 1 sherd had adhesions in combination with a crackled slip.

AR-1931 (Heavy).—A total of 79 (62.7 percent) of the ceramic artifacts recovered from this site showed evidence of fire effects (table 12). Five subsurface artifacts (four from Test Pit 1, Stratum 1, one from Test Pit 2, Stratum 1) showed evidence of burning. Four of the twelve artifacts from Test Pit 1 exhibited light to high spalling, while the artifacts from Test Pit 2, Stratum 1, had light sooting over their entire surface. Artifacts from the surface were very burned. All categories exhibited some degree of sooting. There were 20 ceramics (18.3 percent of surface artifacts) that were highly spalled (fig. 30a). Light to high oxidation was recorded on 28 (25.7 percent) of the surface artifacts. The pigment on painted sherds had been altered on five sherds, and several sherds were vitrified. Adhesions were numerous (N = 16) (fig. 30c), 6 had crackled slips, and 3 had both adhesions and crackled slips.

Discussion.—The ceramic artifacts from site AR-2513, moderate intensity, and AR-1931, high intensity, had the highest percentage of artifacts exhibiting fire effects. Sooting is the dominant fire effect category. Fire effects on subsurface artifacts were present at both of these sites. Nearly half, 47.6 percent, of all surface artifacts at AR-1905 measured vari-

Table 7—Fire effects on ceramic artifacts from AR-1961 (light burn).

	Surface		Test pit 1, stratum 1		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion affected by fire						
No effect	44	71.0	20	100.0	64	78.0
1–25 pct.	1	1.6	—	—	1	1.2
26–50 pct.	3	4.8	—	—	3	3.7
51–75 pct.	3	4.8	—	—	3	3.7
76–100 pct.	11	17.7	—	—	11	13.4
Total	62	100.0	20	100.0	82	100.0
Sooting						
None	52	83.9	20	100.0	72	87.8
Light (76–100 pct.)	2	3.2	—	—	2	2.4
Medium (26–50 pct.)	2	3.2	—	—	2	2.4
Medium (76–100 pct.)	6	9.7	—	—	6	7.3
Total	62	100.0	20	100.0	82	100.0
Spalling						
None	56	90.3	20	100.0	76	92.7
Light (1–25 pct.)	2	3.2	—	—	2	2.4
Medium (51–75 pct.)	1	1.6	—	—	1	1.2
Medium (76–100 pct.)	1	1.6	—	—	1	1.2
High (26–50 pct.)	2	3.2	—	—	2	2.4
Total	62	100.0	20	100.0	82	100.0
Oxidation						
None	62	100.0	20	100.0	82	100.0
Total	62	100.0	20	100.0	82	100.0
Pigment						
No effect	60	96.8	20	100.0	80	97.6
Vitrified	1	1.6	—	—	1	1.2
Color altered	1	1.6	—	—	1	1.2
Total	62	100.0	20	100.0	82	100.0
Other physical alterations						
None	57	91.9	20	100.0	77	93.9
Crackled slip	4	6.5	—	—	4	4.9
Adhesions/crackled slip	1	1.6	—	—	1	1.2
Total	62	100.0	20	100.0	82	100.0

ous degrees of sooting. Adhesions were most pronounced at AR-1930, with 21.8 percent of all surface artifacts affected, and AR-1931 with 14.7 percent of all surface artifacts affected.

Summary of Fire Effects on Ceramic Artifacts

A significant result of this analysis is that 47.5 percent of the ceramic artifacts recovered from burned sites were fire-altered to some extent. Usually, more than half of the surface of the item exhibited some form of thermal alteration. As mentioned above, sooting is the dominant fire effect category. Although no other studies are available with which to compare these data, this appears to be a high proportion, considering the figure represents all artifacts (both surface and subsurface) from all categories (light to heavy burn intensity). A summary of the fire effects is presented in table 13.

The assumption is that fire effects would conform to the expected pattern, i.e., artifacts recovered from sites in the low intensity burn areas would exhibit low damage from fire, and the damage would rise exponentially through the moderate and high categories. Results of the ceramic artifact analysis were compared to these expected results. A Chi-square test of data in tables 7–12 shows significant differences

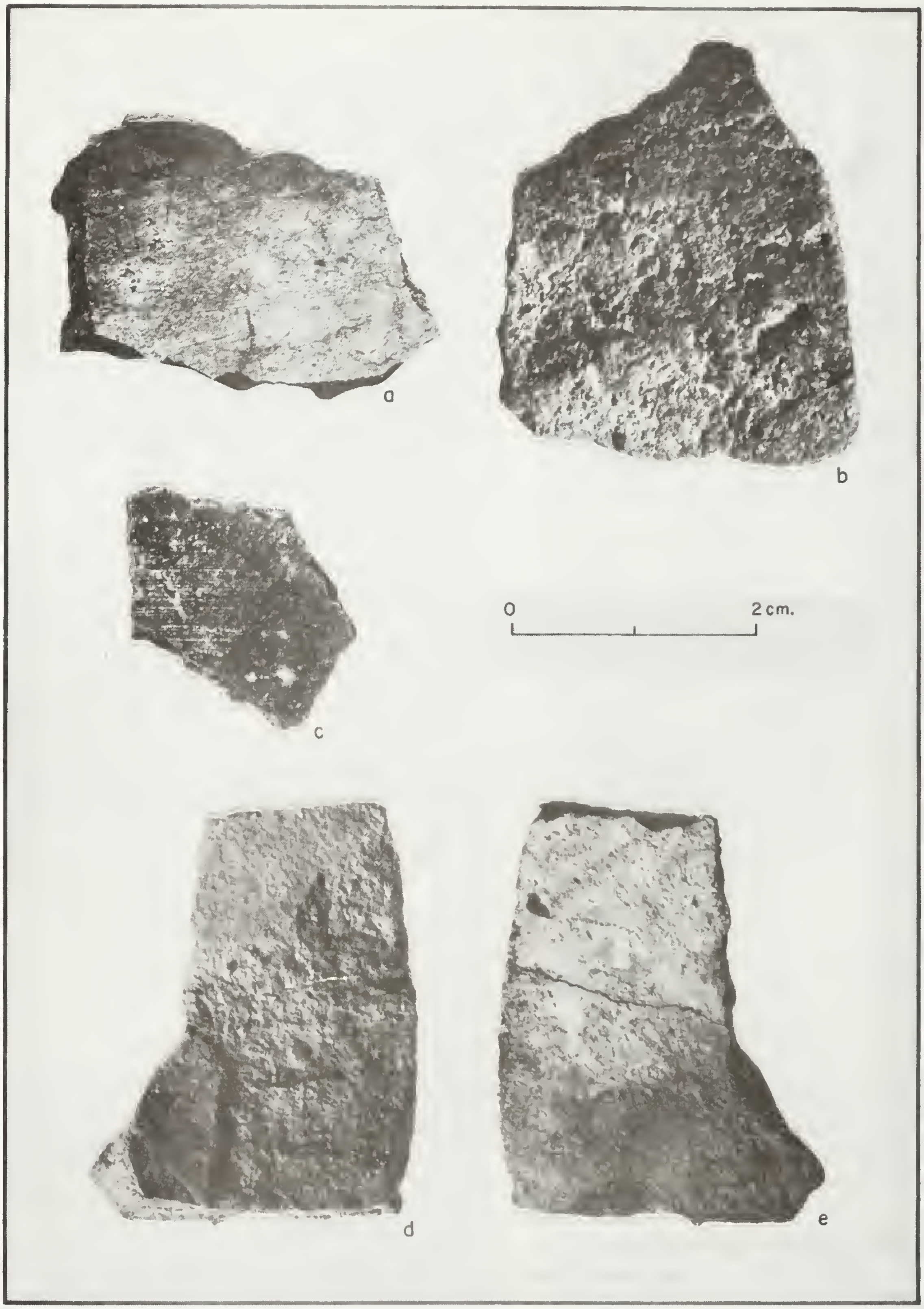

Figure 29—Examples of pottery affected by fire: (a) AR-1961, sooting and crazing on white ware sherd from the burned log area; (b) AR-2513, Jemez Utility ware exhibiting medium sooting; (c) AR 2513, adhesions on a white ware sherd; (d) AR-1930, heavily fire-damaged white ware sherd exhibiting spalling and cracking, interior and exterior views.

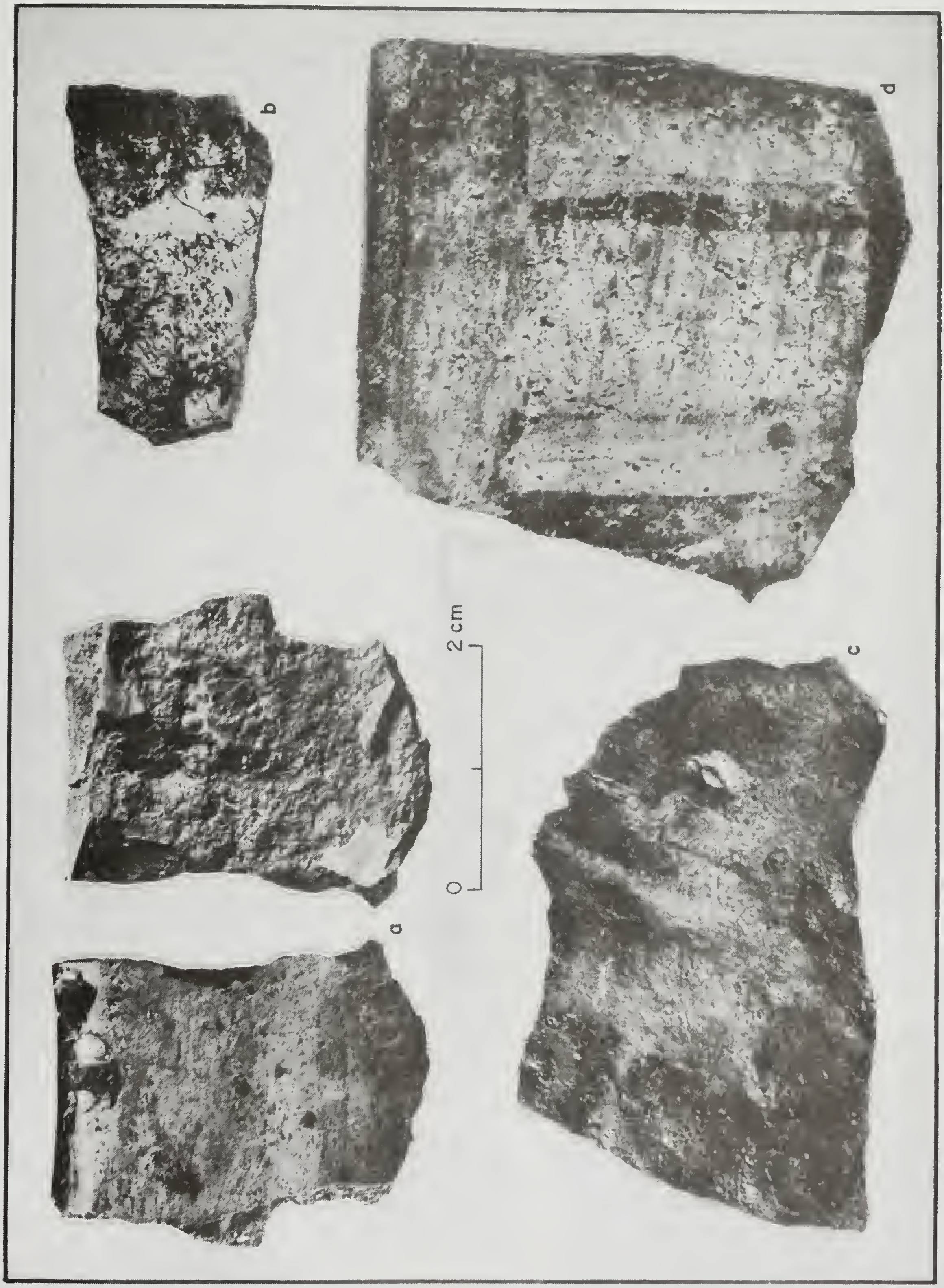

Figure 30—Examples of pottery affected by fire: (a) AR-1931, heavily spalled white ware sherd, interior and exterior view; (b) AR-1930, heavy adhesions on white ware sherd; (c) AR-1931, adhesions on a white ware sherd from a heavily burned site; (d) AR-1930, heavily burned polychrome sherd.

Table 8—Fire effects on ceramic artifacts from AR-2516 (light burn).

	Surface		Test pit 1, stratum 1		Test pit 1, stratum 2		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion affected by fire								
No effect	45	54.9	23	100.0	3	100.0	71	65.7
1–25 pct.	5	6.1	—	—	—	—	5	4.6
26–50 pct.	19	23.2	—	—	—	—	19	17.6
51–75 pct.	3	3.7	—	—	—	—	3	2.8
76–100 pct.	10	12.2	—	—	—	—	10	9.3
Total	82	100.0	23	100.0	3	100.0	108	100.0
Sooting								
None	61	74.4	23	100.0	3	100.0	87	80.6
Light (1–25 pct.)	3	3.7	—	—	—	—	3	2.8
Light (26–50 pct.)	7	8.5	—	—	—	—	7	6.5
Light (51–75 pct.)	2	2.4	—	—	—	—	2	1.9
Light (76–100 pct.)	6	7.3	—	—	—	—	6	5.6
Medium (1–25 pct.)	1	1.2	—	—	—	—	1	.9
Medium (26–50 pct.)	1	1.2	—	—	—	—	1	.9
Medium (51–75 pct.)	1	1.2	—	—	—	—	1	.9
Total	82	100.0	23	100.0	3	100.0	108	100.0
Spalling								
None	79	96.3	23	100.0	3	100.0	105	97.2
Light (26–50 pct.)	3	3.7	—	—	—	—	3	2.8
Total	82	100.0	23	100.0	3	100.0	108	100.0
Oxidation								
None	65	79.3	23	100.0	3	100.0	91	84.3
Light (1–25 pct.)	1	1.2	—	—	—	—	1	—9
Light (26–50 pct.)	3	3.7	—	—	—	—	3	2.8
Light (76–100 pct.)	1	1.2	—	—	—	—	1	—9
Medium (26–50 pct.)	10	12.2	—	—	—	—	10	9.3
Medium (51–75 pct.)	2	2.4	—	—	—	—	2	1.9
Total	82	100.0	23	100.0	3	100.0	108	100.0
Pigment								
No effect	82	100.0	23	100.0	3	100.0	108	100.0
Total	82	100.0	23	100.0	3	100.0	108	100.0
Other physical alterations								
None	79	96.3	23	100.0	3	100.0	105	97.2
Crackled slip	2	2.4	—	—	—	—	2	1.9
Adhesions/crackled slip	1	1.2	—	—	—	—	1	.9
Total	82	100.0	23	100.0	3	100.0	108	100.0

at the <.001 level (fire intensity by affected portion; degrees of freedom = 8). This test demonstrates that there is a relationship between artifact impact and fire intensity, but the statistical relationship is not entirely predictable. For example, a site located in a moderate burn area (AR-2513) yielded a higher total percentage of fire-damaged artifacts than both of the heavily burned sites, AR-1930 and AR-1931. Moreover, subsurface artifacts from AR-2513 showed fire effects 20 cm below the surface, while at AR 1931, subsurface damage to artifacts was confined to the top 10 cm level. This high percentage of burn artifacts and intensity of effects exhibited at AR-2513 was largely due to the presence of several artifacts within a large BLA.

Discussion

Preliminary results of the ceramic analysis suggest that there are significant impacts to this artifact class regardless of fire intensity. For example, at a lightly burned site (AR-1961), ceramic artifacts from the midden showed substantial effects from the fire. The remainder of the artifacts on the site, however, were

Table 9—Fire effects on ceramic artifacts from AR-1905 (moderate burn).

	Surface		Test pit 1, stratum 1		Test pit 1, stratum 2		Test pit 2, stratum 1		Test pit 2, stratum 2		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion affected by fire												
No effect	81	48.2	24	100.0	5	100.0	2	100.0	3	100.0	115	56.9
1–25 pct.	29	17.3	—	—	—	—	—	—	—	—	29	14.4
26–50 pct.	11	6.5	—	—	—	—	—	—	—	—	11	5.4
51–75 pct.	4	2.4	—	—	—	—	—	—	—	—	4	2.0
76–100 pct.	43	25.6	—	—	—	—	—	—	—	—	43	21.3
Total	168	100.0	24	100.0	5	100.0	2	100.0	3	100.0	202	100.0
Sooting												
None	88	52.4	24	100.0	5	100.0	2	100.0	3	100.0	122	60.4
Light (1–25pct.)	14	8.3	—	—	—	—	—	—	—	—	14	6.9
Light (26–50pct.)	1	.6	—	—	—	—	—	—	—	—	1	-5
Light (76–100 pct.)	37	22.0	—	—	—	—	—	—	—	—	37	18.3
Medium (1–25 pct.)	8	4.8	—	—	—	—	—	—	—	—	8	4.0
Medium (26–50 pct.)	6	3.6	—	—	—	—	—	—	—	—	6	3.0
Medium (51–75 pct.)	3	1.8	—	—	—	—	—	—	—	—	3	1.5
Medium (76–100 pct.)	3	1.8	—	—	—	—	—	—	—	—	3	1.5
High (1–25 pct.)	6	3.6	—	—	—	—	—	—	—	—	6	3.0
High (51–75 pct.)	2	1.2	—	—	—	—	—	—	—	—	2	1.0
Total	168	100.0	24	100.0	5	100.0	2	100.0	3	100.0	202	100.0
Spalling												
None	161	95.8	24	100.0	5	100.0	2	100.0	3	100.0	195	96.5
Light (1–25 pct.)	4	2.4	—	—	—	—	—	—	—	—	4	2.0
Light (26–50 pct.)	3	1.8	—	—	—	—	—	—	—	—	3	1.5
Total	168	100.0	24	100.0	5	100.0	2	100.0	3	100.0	202	100.0
Oxidation												
None	167	99.4	23	95.8	5	100.0	2	100.0	3	100.0	200	99.0
Light (1–25 pct.)	—	—	1	4.2	—	—	—	—	—	—	1	-5
Light (26–50 pct.)	1	.6	—	—	—	—	—	—	—	—	1	-5
Total	168	100.0	24	100.0	5	100.0	2	100.0	3	100.0	202	100.0
Pigment												
No effect	167	99.4	24	100.0	4	80.0	2	100.0	3	100.0	200	99.0
Color altered	1	.6	—	—	1	20.0	—	—	—	—	2	1.0
Total	168	100.0	24	100.0	5	100.0	2	100.0	3	100.0	202	100.0
Other Physical Alterations												
None	161	95.8	24	100.0	5	100.0	2	100.0	3	100.0	195	96.5
Eroded	1	.6	—	—	—	—	—	—	—	—	1	-5
Adhesions	6	3.6	—	—	—	—	—	—	—	—	6	3.0
Total	168	100.0	24	100.0	5	100.0	2	100.0	3	100.0	202	100.0

not as altered. Artifacts that exhibited the heaviest burning on this site were recovered from a burned log area (BLA). The pronounced fire effects at AR-1961 can be attributed to a dead tree that burned in place on the midden while the rest of the fire passed over the site with much less of an impact.

The effects of logs or fallen branches that have burned in situ on a site must be given serious consideration in this study, as it seems to have measurable consequences on the condition of ceramic artifacts. The equation is simple: because the residence time of the fire is increased by fuel burning in place, the exposure of the artifacts to fire is prolonged. These were the circumstances at sites AR-2513 and AR-1931, where artifacts recovered from BLAs were severely burned. All of the sites in the burned sample, with the exception of AR-1930, had definable BLAs, and these areas were located on or near the structural component of the site.

At AR-2513, a large burning log caused fire effects on the artifacts and subsurface structural materials to a depth in excess of 20 cm.

Table 10—Fire effects on ceramic artifacts from AR-2513 (moderate burn).

	Surface		Test pit 1, stratum 2		Test pit 2, stratum 1		Test pit 2, stratum 2		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion affected by fire										
No effect	25	26.6	1	50.0	5	62.5	6	75.0	37	33.0
1–25 pct.	15	16.0	—	—	—	—	1	12.5	16	14.3
26–50 pct.	34	36.2	1	50.0	1	12.5	1	12.5	37	33.0
51–75 pct.	7	7.4	—	—	—	—	—	—	7	6.3
76–100 pct.	13	13.8	—	—	2	25.0	—	—	15	13.4
Total	94	100.0	2	100.0	8	100.0	8	100.0	112	100.0
Sooting										
None	58	61.7	2	100.0	6	75.0	8	100.0	74	66.1
Light (1–25 pct.)	8	8.5	—	—	—	—	—	—	8	7.1
Light (26–50 pct.)	6	6.4	—	—	—	—	—	—	6	5.4
Light (51–75 pct.)	3	3.2	—	—	—	—	—	—	3	2.7
Light (76–100 pct.)	6	6.4	—	—	2	25.0	—	—	8	7.1
Medium (1–25 pct.)	3	3.2	—	—	—	—	—	—	3	2.7
Medium (26–50 pct.)	7	7.4	—	—	—	—	—	—	7	6.3
Medium (51–75 pct.)	2	2.1	—	—	—	—	—	—	2	1.8
High (51–75 pct.)	1	1.1	—	—	—	—	—	—	1	.9
Total	94	100.0	2	100.0	8	100.0	8	100.0	112	100.0
Spalling										
None	75	79.8	1	50.0	7	87.5	7	87.5	90	80.4
Light (1–25 pct.)	2	2.1	—	—	—	—	1	12.5	3	2.7
Light (26–50 pct.)	1	1.1	—	—	—	—	—	—	1	.9
Medium (1–25 pct.)	1	1.1	—	—	—	—	—	—	1	.9
Medium (26–50 pct.)	7	7.4	—	—	1	12.5	—	—	8	7.1
Medium (51–75 pct.)	2	2.1	—	—	—	—	—	—	2	1.8
High (26–50 pct.)	2	2.1	1	50.0	—	—	—	—	3	2.7
High (51–75 pct.)	1	1.1	—	—	—	—	—	—	1	.9
High (76–100 pct.)	3	3.2	—	—	—	—	—	—	3	2.7
Total	94	100.0	2	100.0	8	100.0	8	100.0	112	100.0
Oxidation										
None	75	79.8	2	100.0	7	87.5	8	100.0	92	82.1
Light (1–25 pct.)	2	2.1	—	—	—	—	—	—	2	1.8
Light (26–50 pct.)	6	6.4	—	—	—	—	—	—	6	5.4
Light (76–100 pct.)	1	1.1	—	—	—	—	—	—	1	.9
Medium (1–25 pct.)	3	3.2	—	—	—	—	—	—	3	2.7
Medium (26–50 pct.)	6	6.4	—	—	1	12.5	—	—	7	6.3
High (26–50 pct.)	1	1.1	—	—	—	—	—	—	1	.9
Total	94	100.0	2	100.0	8	100.0	8	100.0	112	100.0
Pigment										
No effect	91	96.8	2	100.0	8	100.0	7	87.5	108	96.4
Color altered	2	2.1	—	—	—	—	1	12.5	3	2.7
Oxidized	1	1.1	—	—	—	—	—	—	1	.9
Total	94	100.0	2	100.0	8	100.0	8	100.0	112	100.0
Other physical alterations										
None	66	70.2	2	100.0	8	100.0	7	87.5	83	74.1
Adhesions	10	10.6	—	—	—	—	—	—	10	8.9
Crackled slip	10	10.6	—	—	—	—	1	12.5	11	9.8
Adhesions/crackled slip	8	8.5	—	—	—	—	—	—	8	7.1
Total	94	100.0	2	100.0	8	100.0	8	100.0	112	100.0

Table 11—Fire effects on ceramic artifacts from AR-1930 (heavy burn).

	Surface		Test pit 1, stratum 1		Test pit 1, stratum 2		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion affected by fire								
No effect	77	41.0	7	100.0	9	100.0	93	45.6
1–25 pct.	29	15.4	—	—	—	—	29	14.2
26–50 pct.	46	24.5	—	—	—	—	46	22.5
51–75 pct.	19	10.1	—	—	—	—	19	9.3
76–100 pct.	17	9.0	—	—	—	—	17	8.3
Total	188	100.0	7	100.0	9	100.0	204	100.0
Sooting								
None	138	73.4	7	100.0	9	100.0	154	75.5
Light (1–25 pct.)	12	6.4	—	—	—	—	12	5.9
Light (26–50 pct.)	6	3.2	—	—	—	—	6	2.9
Light (51–75 pct.)	1	.5	—	—	—	—	1	.5
Light (76–100 pct.)	3	1.6	—	—	—	—	3	1.5
Medium (1–25 pct.)	8	4.3	—	—	—	—	8	3.9
Medium (26–50 pct.)	12	6.4	—	—	—	—	12	5.9
Medium (51–75 pct.)	3	1.6	—	—	—	—	3	1.5
High (26–50 pct.)	2	1.1	—	—	—	—	2	1.0
High (51–75 pct.)	3	1.6	—	—	—	—	3	1.5
Total	188	100.0	7	100.0	9	100.0	204	100.0
Spalling								
None	167	88.8	7	100.0	9	100.0	183	89.7
Light (1–25 pct.)	2	1.1	—	—	—	—	2	1.0
Light (26–50 pct.)	11	5.9	—	—	—	—	11	5.4
Light (51–75 pct.)	6	3.2	—	—	—	—	6	2.9
Medium (26–50 pct.)	2	1.1	—	—	—	—	2	1.0
Total	188	100.0	7	100.0	9	100.0	204	100.0
Oxidation								
None	148	78.7	7	100.0	9	100.0	164	80.4
Light (1–25 pct.)	6	3.2	—	—	—	—	6	2.9
Light (26–50 pct.)	15	8.0	—	—	—	—	15	7.4
Light (51–75 pct.)	6	3.2	—	—	—	—	6	2.9
Light (76–100 pct.)	8	4.3	—	—	—	—	8	3.9
Medium (26–50 pct.)	1	.5	—	—	—	—	1	.5
Medium (51–75 pct.)	1	.5	—	—	—	—	1	.5
Medium (76–100 pct.)	1	.5	—	—	—	—	1	.5
High (76–100 pct.)	2	1.1	—	—	—	—	2	1.0
Total	188	100.0	7	100.0	9	100.0	204	100.0
Pigment								
No effect	183	97.3	7	100.0	9	100.0	199	97.5
Color altered	5	2.7	—	—	—	—	5	2.5
Total	188	100.0	7	100.0	9	100.0	204	100.0
Other physical alterations								
None	140	74.5	7	100.0	9	100.0	156	76.5
Warped	1	.5	—	—	—	—	1	.5
Adhesions	41	21.8	—	—	—	—	41	20.1
Crackled slip	5	2.7	—	—	—	—	5	2.5
Adhesions/crackled slip	1	.5	—	—	—	—	1	.5
Total	188	100.0	7	100.0	9	100.0	204	100.0

Table 12—Fire effects on ceramic artifacts from AR-1931 (heavy burn).

	Surface		Test pit 1, stratum 1		Test pit 2, stratum 1		Test pit 2, stratum 2		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion affected by fire										
No effect	35	32.1	8	66.7	—	—	4	100.0	47	37.3
1–25 pct.	10	9.2	1	8.3	—	—	—	—	11	8.7
26–50 pct.	22	20.2	3	25.0	—	—	—	—	25	19.8
51–75 pct.	12	11.0	—	—	—	—	—	—	12	9.5
76–100 pct.	30	27.5	—	—	1	100.0	—	—	31	24.6
Total	109	100.0	12	100.0	1	100.0	4	100.0	126	100.0
Sooting										
None	76	69.7	12	100.0	—	—	4	100.0	92	73.0
Light (1–25 pct.)	3	2.8	—	—	—	—	—	—	3	2.4
Light (26–50 pct.)	7	6.4	—	—	—	—	—	—	7	5.6
Light (51–75 pct.)	1	.9	—	—	—	—	—	—	1	-8
Light (76–100 pct.)	2	1.8	—	—	1	100.0	—	—	3	2.4
Medium (1–25 pct.)	1	.9	—	—	—	—	—	—	1	-8
Medium (26–50 pct.)	6	5.5	—	—	—	—	—	—	6	4.8
Medium (51–75 pct.)	4	3.7	—	—	—	—	—	—	4	3.2
Medium (76–100 pct.)	3	2.8	—	—	—	—	—	—	3	2.4
High (26–50 pct.)	1	.9	—	—	—	—	—	—	1	.8
High (51–75 pct.)	3	2.8	—	—	—	—	—	—	3	2.4
High (76–100 pct.)	2	1.8	—	—	—	—	—	—	2	1.6
Total	109	100.0	12	100.0	1	100.0	4	100.0	126	100.0
Spalling										
None	78	71.6	8	66.7	—	—	4	100.0	90	71.4
Light (1–25 pct.)	3	2.8	1	8.3	—	—	—	—	4	3.2
Light (26–50 pct.)	2	1.8	—	—	—	—	—	—	2	1.6
Medium (1–25 pct.)	5	4.6	1	8.3	—	—	—	—	6	4.8
Medium (26–50 pct.)	1	.9	—	—	—	—	—	—	1	.8
Medium (51–75 pct.)	—	—	—	—	1	100.0	—	—	1	.8
High (26–50 pct.)	15	13.8	2	16.7	—	—	—	—	17	13.5
High (51–75 pct.)	3	2.8	—	—	—	—	—	—	3	2.4
High (76–100 pct.)	2	1.8	—	—	—	—	—	—	2	1.6
Total	109	100.0	12	100.0	1	100.0	4	100.0	126	100.0
Oxidation										
None	81	74.3	11	91.7	—	—	4	100.0	96	76.2
Light (1–25 pct.)	2	1.8	1	8.3	1	100.0	—	—	4	3.2
Light (26–50 pct.)	6	5.5	—	—	—	—	—	—	6	4.8
Light (51–75 pct.)	4	3.7	—	—	—	—	—	—	4	3.2
Light (76–100 pct.)	6	5.5	—	—	—	—	—	—	6	4.8
Medium (26–50 pct.)	3	2.8	—	—	—	—	—	—	3	2.4
Medium (51–75 pct.)	3	2.8	—	—	—	—	—	—	3	2.4
Medium (76–100 pct.)	2	1.8	—	—	—	—	—	—	2	1.6
High (26–50 pct.)	1	.9	—	—	—	—	—	—	1	.8
High (76–100 pct.)	1	.9	—	—	—	—	—	—	1	.8
Total	109	100.0	12	100.0	1	100.0	4	100.0	126	100.0
Pigment										
No effect	104	95.4	12	100.0	1	100.0	4	100.0	121	96.0
Crackled	1	.9	—	—	—	—	—	—	1	.8
Vitrified	1	.9	—	—	—	—	—	—	1	.8
Vaporized	1	.9	—	—	—	—	—	—	1	.8
Color altered	2	1.8	—	—	—	—	—	—	2	1.6
Total	109	100.0	12	100.0	1	100.0	4	100.0	126	100.0
Other physical alterations										
None	82	75.2	12	100.0	1	100.0	4	100.0	99	78.6
Vitrified	2	1.8	—	—	—	—	—	—	2	1.6
Adhesions	16	14.7	—	—	—	—	—	—	16	12.7
Crackled slip	6	5.5	—	—	—	—	—	—	6	4.8
Adhesions/crackled slip	3	2.8	—	—	—	—	—	—	3	2.4
Total	109	100.0	12	100.0	1	100.0	4	100.0	126	100.0

Table 13—Frequencies of fire-affected ceramic artifacts.

	AR-1961 Light (pct.)	AR-2516 Light (pct.)	AR-1905 Moderate (pct.)	AR-2513 Moderate (pct.)	AR-1930 Heavy (pct.)	AR-1931 Heavy (pct.)
Surface artifacts	29.0	45.1	51.8	73.4	59.0	67.9
Subsurface artifacts	0.0	0.0	0.0	33.3	0.0	29.4
Surface artifacts (as percentage of total artifacts)	22.0	34.3	43.1	61.6	54.4	58.7
Subsurface artifacts (as percentage of total artifacts)	0.0	0.0	0.0	5.4	0.0	4.0
Total artifacts	22.0	34.3	43.1	67.0	54.4	62.7

The subsurface burning at AR-1931 was largely the result of the combined effect of a burning log resting on the structure, and burning roots that had been ignited by the log.

Our preliminary conclusions are that if the fuel load was removed from the sites, there would be a return to the general pattern (the more intense the fire, the more intense the effect). This would enable predictions to be made concerning fire behavior and its affect on ceramic artifacts. Standing dead trees in the vicinity of the site may also be a problem, as they may catch fire and collapse onto the site.

Implications for Future Studies

Research Question No. 7 (see Research Framework) addresses the question of whether or not observed changes due to fire effects make a difference in site interpretation. Several fire effects related to the Henry Fire were identified earlier. These were sooting, spalling, oxidation, pigment, and other physical alterations.

Evidence of potential negative fire effects was recognized early in the project. During preliminary reconnaissance at AR-1931, several black-on-white and polychrome sherds had been so altered (crackled slip, vitrification, and color-altered) that field identification by pottery type was nearly impossible (fig. 30d). The inability to accurately identify diagnostic pottery in the field is a major concern, since management decisions and evaluations of significance are made based on these data. Because of the combined changes to color and composition of the sherds, the ceramics at AR-1961 were initially thought to be glaze wares. Subsequent laboratory work identified these items as Jemez Black-on-white whose carbon pigment had vitrified to resemble glaze paint, and whose slip had turned orange through oxidation. Given the temporal distribution of both types (Glaze wares: A.D. 1200–1350; and Jemez Black-on-white: A.D. 1300–1750), the importance of accurate identification for chronological placement of the site is self-evident. As it happens, glaze wares were also present on the site (Puname Polychrome: A.D. 1680–1740), which added another dimension to site interpretation. This suggests that there is a substantial change in the appearance and diagnostic capabilities of ceramics as a consequence of exposure to fire. In this example, the typological difficulties were the result of the combined effects of oxidation, vitrification, and crackling.

Spalling, the removal of surface areas of the sherd because of heat buildup, may also contribute to obscuring the surface characteristics of ceramic artifacts and may hinder field identification. Because of spalling, critical design characteristics may be removed from a sherd. Although design elements were lacking on several items during the analysis, typological identification was possible.

High frequencies of adhesions were monitored for sites AR-1930 and AR-1931, both sites from the heavily burned areas, and high frequencies of sooting were recorded for AR-1905.

Traylor et al. (1990) emphasizes adhesions on artifacts as one of the more prominent side effects of the La Mesa Fire. The frequency of adhesions (an unidentified sticky organic residue) was high on ceramic artifacts from both of the heavily burned sites (AR-1930 and AR-1931). The origin of the adhesions are unknown; however, there seems to be a correlation between fire intensity and the presence of adhesions. It was noted that adhesions appear to be confined to surface artifacts. Speculatively, pine sap, burning pine needles, or some other organic substance may be responsible for these deposits. Further research may determine the origin of adhesions and their chemical makeup. Although identifying a sherd by type was rendered more difficult by these adhesions, they rarely obscured an item to the point where identification became problematic. Diagnostic potential notwithstanding, there may be some concern that the

long-term preservation of a ceramic artifact is compromised by the presence of a residue of unknown chemical composition.

Sooting was nearly ubiquitous on artifacts exhibiting fire effects, particularly at AR-1905. The definition used to code this attribute was based on the analyst's judgment of what constituted sooting directly related to the Henry Fire (see definition above). Sooting was coded as "recent" (attributed to the Henry Fire) if the soot was loosely adhering to the surface of the item and could easily be removed. In the short term, large particles of soot adhering to an artifact does not facilitate analysis. In the long run, sooting may be a temporary condition, which may dissipate over time in the field due to natural factors (erosion, rain, wind, or snowfall) or be removed during lab processing. Sherds without recent sooting within the assemblage maintained an overall gray color. This may be the cumulative effect of repeated sooting episodes over time. While temporary sooting may erode away or wash off during processing, cumulative soot buildup may result in staining or smudging a sherd and altering the color. During field analysis, an area of possible ambiguity might include the initial recognition and documentation of a pottery type. In a hypothetical example, a gray-stained Jemez-black-on-white sherd (slipped "oyster-white" on both sides) could conceivably be mistaken for a slipped plain ware, gray ware, or utility sherd. This would mean misclassifying a temporally diagnostic artifact. Hopefully, archaeologists would be alert to this possible area of confusion, particularly if pigment is present on the vessel. Whether sooting has a permanent effect has not been determined, and the degree to which it might affect accurate data collection is unknown. In this study, however, oxidation, vitrification, sooting, spalling, and adhesions were identified as the major fire effects on ceramic artifacts.

GROUND-STONE ARTIFACT ANALYSIS

Stephen C. Lentz, Office of Archaeological Studies

The objective of the analysis was to monitor the effects of fire on ground-stone artifacts. Six ground-stone artifacts were analyzed during the laboratory phase of the project. The artifacts were recovered from surface collections only. Because there was a scarcity of ground-stone artifacts, all surface ground-stone items were collected by their grid designation or were piece-plotted. Ground-stone items were present on three of the seven sites: AR-1961, a lightly burned site; and AR-1930 and AR-1931, heavily burned sites.

Methods

All the ground-stone artifacts recovered during the field phase of the Henry Fire study were analyzed. Standard OAS ground-stone analysis methods were used to gather archaeological information *(Standardized Ground-Stone Artifact Analysis: A Manual for the Office of Archaeological Studies)*. Variables monitored include preform morphology, material type, and function. Attributes monitored for fire effects include portion of the item affected by fire, sooting, oxidation, reduction, other physical alterations (table 14). The same criteria for sooting, oxidation, and adhesions used for ceramic artifacts were used for ground-stone artifacts. Reduction was defined as blackening of the material caused by the artifacts being burned without the presence of oxygen or the presence of organic material on the artifacts. This is different from sooting in that it cannot be removed by rubbing. The ground-stone items were not washed or numbered prior to analysis to preserve the variables needed to determine fire effects.

Fire effects on ground-stone artifacts could be the result of past forest fires, the recent Henry Fire, or possibly when the ground stone was in use by prehistoric peoples. Since it was not always possible to distinguish when the burning occurred on the artifact, monitoring and recording was conservative. For example, sooting as a result of the Henry Fire was coded if the soot was loosely adhering to the surface of the item. Only attributes judged to be recent fire effects were coded. Fire intensities for the sooting, reduction, and oxidation categories were hierarchically ordered according to light, moderate, or high burning; and percentage of surface area affected (table 14).

Analysis Results

All analyzed ground-stone artifacts were fragmentary, and no whole manos or metates were recovered during the study. The ground-stone assemblage is minimal and comprises 0.5 percent (N = 6) of the total artifacts analyzed for the Henry Fire study. The following section presents the results of the standard functional ground-stone analysis, followed by the observed fire effects (specialized analysis). A discussion of the assemblage is site-specific.

Archaeological Analysis

Preform Morphology.—The selection of raw materials chosen for ground-stone tools includes thick slabs of stone (N = 5, 83.3 percent) followed by chunky or angular shapes (N = 1, 16.7 percent).

Material Type.—Sandstone is the dominant material type found (N = 5, 83.3 percent). Rhyolite (N = 1, 16.7 percent) is the only other material represented.

Function.—Four of the ground-stone artifacts were pieces of slab metates (66.7 percent). One of the ground items was a mano fragment (16.7 percent), and the last piece was an irregular-shaped metate (16.7 percent).

Discussion.—Only fragmentary ground-stone artifacts were recovered from three of the seven sites studied in this project. At AR-1930 and AR-1931 only metates were present and at AR-1961, a mano and a metate were collected. The ground-stone items were manufactured primarily from tabular sandstone; one metate fragment was fashioned from rhyolite. Sandstone and rhyolitic material are indigenous to the Jemez Mountains and probably were obtained from local outcroppings of these rock types.

Only very limited inferences can be made about the ground stone found during this study. The three sites (AR-1961, AR-1930, and AR-1931) were Pueblo IV to Pueblo V sites. It is well documented that the settlement system of this time period was characterized by large pueblos with associated small farmstead communities and a sedentary agrarian focus.

It is likely that the ground stone used in this fire study project was utilized for processing domestic and wild plant food species.

Fire Effects Analysis

Portion Affected by Fire.—Three ground-stone artifacts (50 percent) had over 75 percent of their surface altered by fire. One item had a 26–50 percent surface area affected by fire, and another had 1–25 percent of its surface fire-altered. The mano fragment showed no fire effects.

Sooting.—Two items (33.3 percent) did not exhibit any sooting, while one piece of ground stone had medium sooting on 76–100 percent of its surface. Three items exhibited a high degree of sooting covering more than 25 percent of their surfaces.

Table 14—Ground-stone artifact attributes and fire effects.

	AR-1961 Light		AR-1930 Heavy		AR-1931 Heavy		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Preform morphology								
Chunky or angular	1	50.0	—	—	—	—	1	16.7
Slab, thick (>10 cm)	1	50.0	1	100.0	3	100.0	5	83.3
Total	2	100.0	1	100.0	3	100.0	6	100.0
Material								
Rhyolite	1	50.0	—	—	—	—	1	16.7
Sandstone	1	50.0	1	100.0	3	100.0	5	83.3
Total	2	100.0	1	100.0	3	100.0	6	100.0
Function								
Mano, undiff.	1	50.0	—	—	—	—	1	16.7
Metate, undiff.	1	50.0	—	—	—	—	1	16.7
Metate, slab	—	—	1	100.0	3	100.0	4	66.7
Total	2	100.0	1	100.0	3	100.0	6	100.0
Portion affected by fire								
No effect	1	50.0	—	—	—	—	1	16.7
1–25 pct.	1	50.0	—	—	—	—	1	16.7
26–50 pct.	—	—	1	100.0	—	—	1	16.7
76–100 pct.	—	—	—	—	3	100.0	3	50.0
Total	2	100.0	1	100.0	3	100.0	6	100.0
Sooting								
None	2	100.0	—	—	—	—	2	33.3
Medium (76–100 pct.)	—	—	—	—	1	33.3	1	16.7
High (26–50 pct.)	—	—	1	100.0	—	—	1	16.7
High (76–100 pct.)	—	—	—	—	2	66.7	2	33.3
Total	2	100.0	1	100.0	3	100.0	6	100.0
Oxidation								
None	2	100.0	—	—	3	100.0	5	83.3
High (26–50 pct.)	—	—	1	100.0	—	—	1	16.7
Total	2	100.0	1	100.0	3	100.0	6	100.0
Reduction								
None	1	50.0	—	—	3	100.0	4	66.7
Medium (1–25 pct.)	1	50.0	—	—	—	—	1	16.7
High (26–50 pct.)	—	—	1	100.0	—	—	1	16.7
Total	2	100.0	1	100.0	3	100.0	6	100.0
Crazing								
None	2	100.0	1	100.0	3	100.0	6	100.0
Total	2	100.0	1	100.0	3	100.0	6	100.0
Other physical alterations (OPA)								
None	2	100.0	—	—	3	100.0	5	83.3
Adhesions	—	—	1	100.0	—	—	1	16.7
Total	2	100.0	1	100.0	3	100.0	6	100.0

Oxidation.—Eighty-three percent (N = 5) of the ground-stone assemblage did not exhibit oxidation, while one item had a high degree of oxidation on 26–50 percent of its surface.

Reduction.—Two items were reduced; one to a medium degree on 1–25 percent of the artifact while the other was highly reduced on 26–50 percent. Four (66.7 percent) ground-stone artifacts were not reduced by the fire.

Other Physical Alterations.—Adhesions to the surface of the ground-stone artifacts were the only other fire effect noted in this assemblage. One item (16.7 percent) had adhesions present while the remaining five had none.

Discussion.—Five out of six (83 percent) of the ground-stone artifacts recovered from the burned sites were fire-altered to some extent. No ground-stone artifacts were found at the control site, AR-1886. Sooting was the dominant fire effect that was monitored on the assemblage (N = 4). Reduction, oxidation, and adhesions were present on only one of the artifacts.

Fire Effects by Provenience

Fire effects were monitored only on surface ground-stone artifacts because no ground-stone items were recovered from the test pits. The following discussion evaluates the effects of fire per site (lightly burned; moderately burned, and heavily burned). Surface artifacts were collected from three of the sites: AR-1961, a lightly burned site, and AR-1930 and AR-1931, both heavily burned sites.

AR-1961 (Light).—Two ground-stone artifacts were recovered from this site. One was a mano fragment that had not been altered by the Henry Fire. The second item was a metate fragment that had 1–25 percent of the surface spalled to a medium extent by the fire.

AR-1930 (Heavy).—One metate fragment was collected from AR-1930 (fig. 31). Surface damage (26–50 percent) to this artifact included high degrees of sooting, oxidation, and reduction. Adhesions were also noted on the item.

AR-1931 (Heavy).—Three metate fragments all exhibited 76–100 percent surface damage from the Henry Fire. One fragment had medium sooting and two had high sooting. No other fire effects existed.

Discussion.—Fire damage from the Henry Fire has affected ground stone from light and heavily burned sites. At the lightly burned site (AR-1961) the ground-stone items were either not affected or were partly reduced to a blackened state. The heavily burned sites, on the other hand, showed moderate to high burning characteristics. They were affected by the fire over a higher percentage of their surfaces than was found with the lightly burned artifacts. Fire effects on ground-stone artifacts for heavily burned sites included sooting, oxidation, reduction, and some adhesions.

Summary of Fire Effects on Ground-Stone Artifacts

Ground-stone artifacts were found on only three of the six burned sites that were studied during the Henry Fire study, and interpretations are based on only six ground-stone artifacts.

Discussion

It appears that light burning minimally affects the surface of the ground-stone artifacts while heavy burning alters the stone to a high degree. Moderately burned sites did not have any ground-stone present, so it is unknown to what extent a moderate-intensity fire will affect the ground-stone items. Considering the other artifacts (ceramic and lithic artifacts) that were damaged by moderate-intensity fire, it can be assumed that fire effects will be present on medium-burned ground-stone artifacts. Phase II of this study may help to determine the proportion of damage caused on ground-stone artifacts according to the fire intensity. Hopefully, it can be determined at what degree (threshold) ground-stone items of different material types are subjected to adverse burning conditions.

Implications for Future Studies

The results of the ground-stone analysis suggest that, although fire effects were present, the interpretive potential of the artifacts was not substantially altered by the Henry Fire. The sample was small, and not all burn categories were represented. However, questions were raised that have possible implications for future ground-stone studies in which exposure to fire is a variable. Information from ground-stone artifacts could be substantially compromised by fire effects. The elimination of palynological or macrobotanical information from the grinding surface may be one concern. Another potential area of confusion might be the inability to discriminate between fire-cracked rock and spalled ground stone. Prehistorically, ground-stone artifacts have been re-

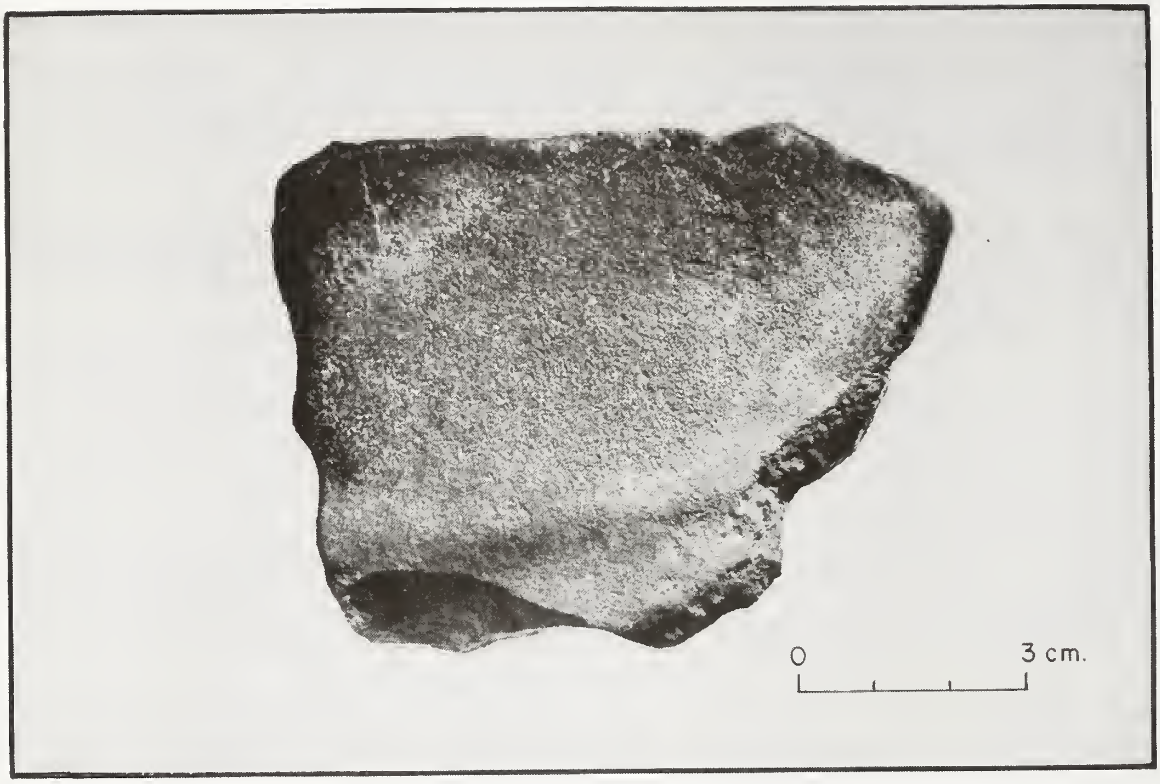

Figure 31—AR-1930, sooted ground stone.

cycled for other uses, such as stone-boiling, and reoccur on the site as fire-cracked rock. If material types such as sandstone or quartzite are used as ground stone, and disintegrate because of exposure to fire, it would be difficult to distinguish fire-cracked rock (e.g., rock that is the by-product of domestic activities) from rock that has been cracked through exposure to natural or prescribed burning. Each category has important implications for site interpretation. Although there was no evidence of any fire-cracked rock or spalled ground stone during Phase I, the possibility of their occurrence on sites subject to burning must be considered. It is suggested that the effects of controlled burning on ground stone be carefully studied during Phase II.

LITHIC ARTIFACT ANALYSIS

Stephen C. Lentz, Office of Archaeological Studies

A total of 125 lithic artifacts were analyzed as part of the laboratory phase. The objective of the analysis was to monitor the fire effects on the recovered assemblage. All of the lithic artifacts recovered during the testing phase were analyzed.

Methods

Lithic artifacts were described in terms of both archaeological characteristics and the apparent fire effects.

Archaeological Analysis

Baseline data for each item were collected according to the criteria outlined in *Standardized Lithic Artifact Analysis: Attributes and Variable Code Lists* compiled by the staff of the Office of Archaeological Studies, Museum of New Mexico (on file, OAS, Museum of New Mexico). Basic attributes recorded on the artifact include morphology, material type, function, cortex, and dimensions. Table 15 is a summary of lithic artifact attributes by site.

Morphology.—Core flakes dominated the morphological assemblage (N = 73, 58 percent). The next most common morphology, angular debris, represented the majority of the remaining assemblage (N = 35, 28 percent).

Material.—Locally available rhyolite was most commonly identified in this assemblage (N = 43, 34 percent). Pedernal chert (N = 25, 20 percent) and obsidian (N = 20, 16 percent) were the next most prevalent material types.

Function.—Most of the lithic artifacts recovered are categorized as unutilized core flakes (N = 70, 56 percent). The second most common function was unutilized angular debris (N = 31, 25 percent).

Cortex.—The majority of the lithic assemblage retained only 0–10 percent of the cortex (N = 85, 68 percent).

Discussion.—The majority of lithic artifacts (N = 108) were core flakes and angular debris and accounted for 86 percent of the total assemblage. This high flake-to-core ratio suggests later stages of core reduction were performed at these sites. A total of nine cores were recovered from the seven sites. The small percent of the total assemblage with cortex suggested that most of the material was transported to the site in a partially decortified state and further cortical reduction occurred at the site. Biface reduction at all seven sites is minimal.

Four formal tools were identified in the total assemblage. These include an unidentified projectile point, an end scraper, a hammerstone, and an undifferentiated biface. Informal tools are also represented by six utilized flakes and one retouched flake.

Fire Effects Analysis

Attributes resulting from fire effects include affected portion, sooting, potlid, oxidation, reduction, crazing, and other physical alterations (adhesions and luster).

Portion of Surface Area.—Of all the lithic artifacts analyzed, both surface and excavated, over half show no signs of fire effects (N = 83, 66 percent) (table 16). Fourteen lithic artifacts (11 percent) exhibit some fire effects on 1–25 percent of the total surface. Eleven artifacts (9 percent) show fire effects on 26–50 percent of their total surface. Five artifacts (4 percent) display burning effects on 51–75 percent of their total surface and 12 artifacts (10 percent) exhibit fire effects on 76–100 percent of their total surface.

Sooting.—Nearly the entire lithic assemblage shows no sooting effects (N = 117, 94 percent). A few artifacts were categorized as having light or medium amounts of sooting on no more than 75 percent of their total surface.

Potlid.—The majority of lithic artifacts did not have potlids (N = 118, 94 percent). One good example of potlids caused by the Henry Fire was a scraper found in the burned soil beneath a charred log at AR-2513 (fig. 32). The potlids were found next to the scraper.

Oxidation.—Most of the lithic artifacts show no signs of oxidation (N = 120, 96 percent). The five artifacts that exhibited light and high amounts of oxidation are from AR-2513.

Reduction.—Two sites, AR-2513 and AR-1886, had lithic artifacts exhibiting signs of reduction representing only 2 percent of the total assemblage. The majority of the assemblage (N = 122, 98 percent) does not show any reduction.

Crazing.—Varying degrees of crazing are found on lithic artifacts at the two moderate fire-intensity sites and the two high fire-intensity sites (N = 15, 12 percent). Crazing is not present on the majority of the assemblage (N = 110, 88 percent).

Table 15—Lithic artifact attributes.

	AR-1961		AR-2516		AR-1905		AR-2513		AR-1930		AR-1931		AR-1886		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Morphology																
Angular debris	—	—	—	—	2	25.0	27	45.8	6	20.0	—	—	—	—	35	28.0
Core flake	3	75.0	5	100.0	4	50.0	22	37.3	23	76.7	6	85.7	10	83.3	73	58.4
Biface flake	—	—	—	—	—	—	—	—	1	3.3	—	—	—	—	1	.8
Potlid	—	—	—	—	—	—	2	3.4	—	—	—	—	—	—	2	1.6
Core, undiff.	—	—	—	—	—	—	—	—	—	—	—	—	1	8.3	1	.8
Unidirectional core	—	—	—	—	—	—	1	1.7	—	—	—	—	—	—	1	.8
Multidirectional core	—	—	—	—	2	25.0	5	8.5	—	—	—	—	—	—	7	5.6
Cobble tool, undiff.	—	—	—	—	—	—	—	—	—	—	—	—	1	8.3	1	.8
Uniface-late stage	—	—	—	—	—	—	1	1.7	—	—	—	—	—	—	1	.8
Biface, undiff.	—	—	—	—	—	—	—	—	—	—	1	14.3	—	—	1	.8
Biface-late stage	1	25.0	—	—	—	—	1	1.7	—	—	—	—	—	—	2	1.6
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0
Material																
Chert, undiff.	1	25.0	—	—	1	12.5	—	—	7	23.3	—	—	—	—	9	7.2
Pedernal chert	—	—	—	—	2	25.0	8	13.6	8	26.7	5	71.4	2	16.7	25	20.0
Chalcedony chert	—	—	—	—	—	—	3	5.1	—	—	—	—	—	—	3	2.4
Silicified wood, undiff.	—	—	—	—	—	—	1	1.7	2	6.7	—	—	1	8.3	4	3.2
Obsidian, undiff.	3	75.0	4	80.0	—	—	—	—	2	6.7	2	28.6	9	75.0	20	16.0
Jemez, generic	—	—	—	—	2	25.0	2	3.4	—	—	—	—	—	—	4	3.2
Polvadera Peak	—	—	—	—	1	12.5	—	—	—	—	—	—	—	—	1	.8
Nonvesicular basalt	—	—	—	—	1	12.5	—	—	—	—	—	—	—	—	1	.8
Rhyolite	—	—	—	—	1	12.5	40	67.8	3	10.0	—	—	—	—	44	35.2
Quartzite, undiff.	—	—	1	20.0	—	—	3	5.1	8	26.7	—	—	—	—	12	9.6
Quartzitic sandstone	—	—	—	—	—	—	2	3.4	—	—	—	—	—	—	2	1.6
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0
Function																
Not applicable	—	—	—	—	—	—	2	3.4	—	—	—	—	1	8.3	3	2.4
Utilized debitage	1	25.0	2	40.0	—	—	1	1.7	—	—	1	14.3	1	8.3	6	4.8
Retouched debitage	—	—	—	—	—	—	—	—	1	3.3	—	—	—	—	1	.8
Hammerstone	—	—	—	—	—	—	—	—	—	—	—	—	1	8.3	1	.8
Unutilized angular debris	—	—	—	—	2	25.0	25	42.4	4	13.3	—	—	—	—	31	24.8
Unutilized flake	2	50.0	3	60.0	4	50.0	23	39.0	25	83.3	5	71.4	8	66.7	70	56.0
Unutilized core	—	—	—	—	2	25.0	6	10.2	—	—	—	—	1	8.3	9	7.2
End/side scraper	—	—	—	—	—	—	1	1.7	—	—	—	—	—	—	1	.8
Biface, undiff.	—	—	—	—	—	—	—	—	—	—	1	14.3	—	—	1	.8
Projectile point, undiff.	1	25.0	—	—	—	—	1	1.7	—	—	—	—	—	—	2	1.6
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0
Cortex (pct.)																
0	2	50.0	1	20.0	1	12.5	34	57.6	21	70.0	5	71.4	4	33.3	68	54.4
10	—	—	1	20.0	1	12.5	8	13.6	3	10.0	1	14.3	3	25.0	17	13.6
20	—	—	—	—	2	25.0	3	5.1	2	6.7	—	—	1	8.3	8	6.4
30	—	—	—	—	1	12.5	2	3.4	1	3.3	—	—	2	16.7	6	4.8
40	2	50.0	—	—	1	12.5	3	5.1	—	—	—	—	—	—	6	4.8
50	—	—	2	40.0	—	—	1	1.7	2	6.7	1	14.3	1	8.3	7	5.6
60	—	—	—	—	—	—	2	3.4	—	—	—	—	1	8.3	3	2.4
70	—	—	—	—	—	—	3	5.1	—	—	—	—	—	—	3	2.4
80	—	—	—	—	1	12.5	1	1.7	—	—	—	—	—	—	2	1.6
90	—	—	1	20.0	1	12.5	2	3.4	—	—	—	—	—	—	4	3.2
100	—	—	—	—	—	—	—	—	1	3.3	—	—	—	—	1	.8
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0

Table 16—Fire effects on lithic artifacts from study sites.

	AR-1961 Light		AR-2516 Light		AR-1905 Moderate		AR-2513 Moderate		AR-1930 Heavy		AR-1931 Heavy		AR-1886 Unburned		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion																
No effect	4	100.0	5	100.0	6	75.0	34	57.6	18	60.0	5	71.4	11	91.7	83	66.4
1–25 pct.	—	—	—	—	1	12.5	10	16.9	3	10.0	—	—	—	—	14	11.2
26–50 pct.	—	—	—	—	—	—	7	11.9	3	10.0	1	14.3	—	—	11	8.8
51–75 pct.	—	—	—	—	—	—	2	3.4	2	6.7	—	—	1	8.3	5	4.0
76–100 pct.	—	—	—	—	1	12.5	6	10.2	4	13.3	1	14.3	—	—	12	9.6
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0
Sooting																
None	4	100.0	5	100.0	7	87.5	56	94.9	28	93.3	6	85.7	11	91.7	117	93.6
Light (1–25 pct.)	—	—	—	—	—	—	2	3.4	—	—	—	—	—	—	2	1.6
Light (26–50 pct.)	—	—	—	—	—	—	—	—	1	3.3	1	14.3	—	—	2	1.6
Light (51–75 pct.)	—	—	—	—	1	12.5	—	—	—	—	—	—	—	—	1	.8
Medium (1–25 pct.)	—	—	—	—	—	—	1	1.7	1	3.3	—	—	—	—	2	1.6
Medium (26–50 pct.)	—	—	—	—	—	—	—	—	—	—	—	—	1	8.3	1	.8
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0
Potlid																
None	4	100.0	5	100.0	8	100.0	55	93.2	29	96.7	6	85.7	11	91.7	118	94.4
Light (1–25 pct.)	—	—	—	—	—	—	—	—	1	3.3	1	14.3	—	—	2	1.6
Light (26–50 pct.)	—	—	—	—	—	—	1	1.7	—	—	—	—	—	—	1	.8
Medium (26–50 pct.)	—	—	—	—	—	—	—	—	—	—	—	—	1	8.3	1	.8
High (26–50 pct.)	—	—	—	—	—	—	2	3.4	—	—	—	—	—	—	2	1.6
High (51–75 pct.)	—	—	—	—	—	—	1	1.7	—	—	—	—	—	—	1	.8
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0
Oxidation																
None	4	100.0	5	100.0	8	100.0	54	91.5	30	100.0	7	100.0	12	100.0	120	96.0
Light (1–25 pct.)	—	—	—	—	—	—	1	1.7	—	—	—	—	—	—	1	.8
High (76–100 pct.)	—	—	—	—	—	—	4	6.8	—	—	—	—	—	—	4	3.2
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0
Reduction																
None	4	100.0	5	100.0	8	100.0	57	96.6	30	100.0	7	100.0	11	91.7	122	97.6
Light (1–25 pct.)	—	—	—	—	—	—	1	1.7	—	—	—	—	—	—	1	.8
Medium (26–50 pct.)	—	—	—	—	—	—	1	1.7	—	—	—	—	1	8.3	2	1.6
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0
Crazing																
None	4	100.0	5	100.0	7	87.5	52	88.1	24	80.0	6	85.7	12	100.0	110	88.0
Light (1–25 pct.)	—	—	—	—	1	12.5	2	3.4	—	—	—	—	—	—	3	2.4
Light (26–50 pct.)	—	—	—	—	—	—	—	—	2	6.7	—	—	—	—	2	1.6
Medium (26–50 pct.)	—	—	—	—	—	—	—	—	1	3.3	—	—	—	—	1	.8
Medium (51–75 pct.)	—	—	—	—	—	—	3	5.1	—	—	—	—	—	—	3	2.4
Medium (76–100 pct.)	—	—	—	—	—	—	—	—	1	3.3	1	14.3	—	—	2	1.6
High (1–25 pct.)	—	—	—	—	—	—	1	1.7	—	—	—	—	—	—	1	.8
High (26–50 pct.)	—	—	—	—	—	—	1	1.7	2	6.7	—	—	—	—	3	2.4
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0
Other physical alterations (OPA)																
None	4	100.0	5	100.0	8	100.0	38	64.4	21	70.0	7	100.0	12	100.0	95	76.0
Adhesions	—	—	—	—	—	—	5	8.5	9	30.0	—	—	—	—	14	11.2
Luster	—	—	—	—	—	—	12	20.3	—	—	—	—	—	—	12	9.6
Adhesions and luster	—	—	—	—	—	—	4	6.8	—	—	—	—	—	—	4	3.2
Total	4	100.0	5	100.0	8	100.0	59	100.0	30	100.0	7	100.0	12	100.0	125	100.0

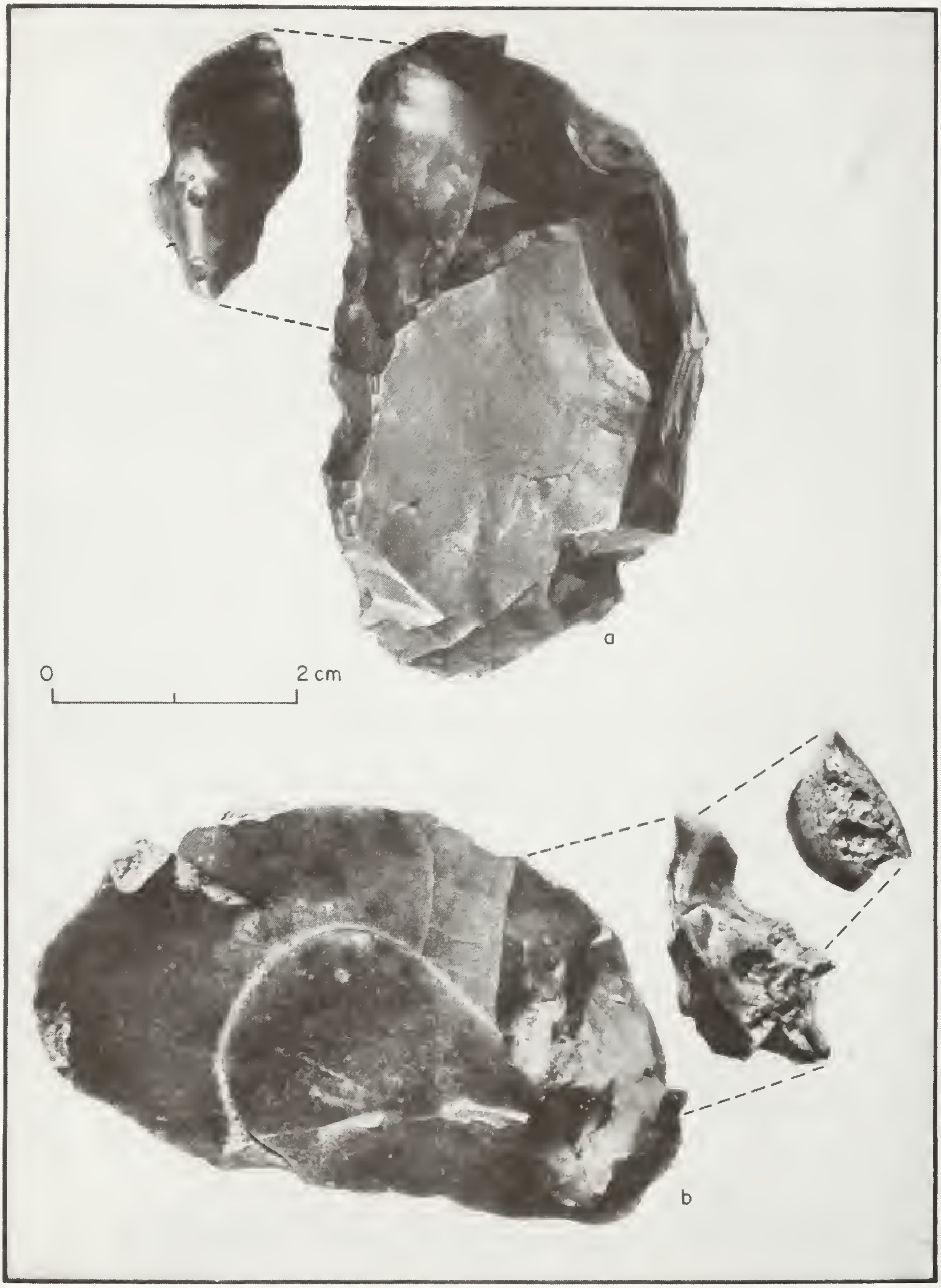

Figure 32—AR-2513, ventral and dorsal views of chert scraper with potlids recovered beneath a charred log.

Other Physical Alterations.—A variety of other physical alterations were monitored during lithic analysis. The most common types of alterations are adhesions, luster, or a combination of both. Although most of the artifacts did not show any other physical alterations (N = 95, 76 percent), one-quarter of the entire assemblage (N = 30, 24 percent) did exhibit adhesions, luster, or a combination of the two.

Discussion.—The 125 lithic artifacts analyzed are 12.9 percent of the artifact assemblage from the burned sites. Of this total, 34 percent exhibited some fire effects, all of which were from moderate and heavily burned sites. The control site contained one lithic artifact that exhibited burning effects, yet this cannot be attributed to the recent Henry Fire. The largest sample of burned lithic artifacts was recovered from AR-2513, a moderately burned site. This is from one test pit excavated in a BLA that contained numerous highly burned artifacts. The degree of sooting varied from light to moderate. This may be due to the time that has elapsed and precipitation that has fallen since the fire occurred in July 1991.

During analysis, it appeared that the lithic material in general had a noticeable lack of sooting when compared with the ceramics. This may be caused by the rates at which soot erodes from materials of different hardness. Potlids were most common on artifacts recovered in the test pit beneath the burned log at AR-2513. Within the top 10 cm of completely blackened soil, a chert scraper was located that had been exposed to a long residence time from a burning log. This item had potlids removed from both sides, as well as an incipient potlid at the point of detachment (fig. 32). Oxidation and reduction were noted on seven lithic artifacts. It was not determined whether this result was from the fire or from heat treatment. Crazing was recorded on lithic artifacts at both moderate and heavily burned sites. Adhesions and luster, comprising the other physical alterations category, were most commonly found on the artifacts from the test pit at AR-2513.

Fire Effects by Site

Effects of varying fire intensity (light, moderate, heavy) were monitored at each site on lithic artifacts collected from the surface and those recovered from the excavation of test pits.

AR-1961 (Light).—AR-1961 exhibited no fire effects on the surface or excavated lithic artifacts (N = 4, 100 percent). When the site burned, only the top layer of duff was consumed. Artifacts at the bottom of the duff were not changed.

AR-2516 (Light).—Neither surface nor excavated lithic artifacts were affected by the fire (N = 5, 100 percent) at this lightly burned site. The top layer of humus protected most of the artifacts on the surface.

AR-1905 (Moderate).—Two artifacts from AR-1905 exhibited light sooting and crazing on their surfaces (29 percent of the surface artifacts) (table 17). The one lithic artifact recovered from a subsurface layer did not show any signs of burning. The humus layer was completely burned at this site, causing the ground to become charred in the top 2–3 cm.

AR-2513 (Moderate).—Nearly half (N = 20, 43 percent) of the surface lithic artifacts at AR-2513 exhibited some sign of burning (fig. 33a). With the exception of Test Pit 1, all lithic artifacts recovered from substrate layers did not show any effects from the Henry Fire. The excavated lithic artifacts from Test Pit 1 did exhibit fire effects (N = 4, 66.7 percent). This pit extended to a 10-cm depth, beneath a burned log with (presumably) a long residence time. These sub-

Table 17—Fire effects on lithic artifacts from AR-1905 (light burn).

	Surface		Test pit 1, stratum 1		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion						
No effect	5	71.4	1	100.0	6	75.0
1–25 pct.	1	14.3	—	—	1	12.5
76–100 pct.	1	14.3	—	—	1	12.5
Total	7	100.0	1	100.0	8	100.0
Sooting						
None	6	85.7	1	100.0	7	87.5
Light (51–75 pct.)	1	14.3	—	—	1	12.5
Total	7	100.0	1	100.0	8	100.0
Potlid						
None	7	100.0	1	100.0	8	100.0
Total	7	100.0	1	100.0	8	100.0
Oxidation						
None	7	100.0	1	100.0	8	100.0
Total	7	100.0	1	100.0	8	100.0
Reduction						
None	7	100.0	1	100.0	8	100.0
Total	7	100.0	1	100.0	8	100.0
Crazing						
None	6	85.7	1	100.0	7	87.5
Light (1–25 pct.)	1	14.3	—	—	1	12.5
Total	7	100.0	1	100.0	8	100.0
Other physical alterations (OPA)						
None	7	100.0	1	100.0	8	100.0
Total	7	100.0	1	100.0	8	100.0

Figure 33—Various lithic artifacts affected by fire: (a) AR-2513, sooted rhyolite artifact; (b) AR-1930, subsurface lithic artifact exhibiting adhesions and crazing; (c) AR-1931, potlid removed from the ventral side of an obsidian artifact.

surface lithic artifacts had 76–100 percent of their total surface affected by fire. Branches from the tree had lodged into the ground and burned, penetrating the soil matrix to the surrounding artifacts. A few lithic artifacts from Test Pit 2, Stratum 2, had some burning effects, probably caused by an earlier fire event (table 18). The highest percentage of adhesions and luster were found to be on surface artifacts (N = 16, 34 percent of surface artifacts).

AR-1930 (Heavy).—AR-1930 had the highest percentage of surface artifacts exhibiting the effects of burning. Half of the surface lithic artifacts at AR-1930

Table 18—Fire effects on lithic artifacts from AR-2513 (moderate burn).

	Surface		Test pit 1, stratum 1		Test pit 1, stratum 2		Test pit 2, stratum 1		Test pit 2, stratum 2		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion												
No effect	27	57.4	1	100.0	1	20.0	2	100.0	3	75.0	34	57.6
1–25 pct.	10	21.3	—	—	—	—	—	—	—	—	10	16.9
26–50 pct.	6	12.8	—	—	—	—	—	—	1	25.0	7	11.9
51–75 pct.	2	4.3	—	—	—	—	—	—	—	—	2	3.4
76–100 pct.	2	4.3	—	—	4	80.0	—	—	—	—	6	10.2
Total	47	100.0	1	100.0	5	100.0	2	100.0	4	100.0	59	100.0
Sooting												
None	44	93.6	1	100.0	5	100.0	2	100.0	4	100.0	56	94.9
Light (1–25 pct.)	2	4.3	—	—	—	—	—	—	—	—	2	3.4
Medium (1–25 pct.)	1	2.1	—	—	—	—	—	—	—	—	1	1.7
Total	47	100.0	1	100.0	5	100.0	2	100.0	4	100.0	59	100.0
Potlid												
None	46	97.9	1	100.0	2	40.0	2	100.0	4	100.0	55	93.2
Light (26–50 pct.)	1	2.1	—	—	—	—	—	—	—	—	1	1.7
High (26–50 pct.)	—	—	—	—	2	40.0	—	—	—	—	2	3.4
High (51–75 pct.)	—	—	—	—	1	20.0	—	—	—	—	1	1.7
Total	47	100.0	1	100.0	5	100.0	2	100.0	4	100.0	59	100.0
Oxidation												
None	46	97.9	1	100.0	1	20.0	2	100.0	4	100.0	54	91.5
Light (1–25 pct.)	1	2.1	—	—	—	—	—	—	—	—	1	1.7
High (76–100 pct.)	—	—	—	—	4	80.0	—	—	—	—	4	6.8
Total	47	100.0	1	100.0	5	100.0	2	100.0	4	100.0	59	100.0
Reduction												
None	45	95.7	1	100.0	5	100.0	2	100.0	4	100.0	57	96.6
Light (1–25 pct.)	1	2.1	—	—	—	—	—	—	—	—	1	1.7
Medium (26–50 pct.)	1	2.1	—	—	—	—	—	—	—	—	1	1.7
Total	47	100.0	1	100.0	5	100.0	2	100.0	4	100.0	59	100.0
Crazing												
None	44	93.6	1	100.0	2	40.0	2	100.0	3	75.0	52	88.1
Light (1–25 pct.)	2	4.3	—	—	—	—	—	—	—	—	2	3.4
Medium (51–75 pct.)	1	2.1	—	—	2	40.0	—	—	—	—	3	5.1
High (1–25 pct.)	—	—	—	—	1	20.0	—	—	—	—	1	1.7
High (26–50 pct.)	—	—	—	—	—	—	—	—	1	25.0	1	1.7
Total	47	100.0	1	100.0	5	100.0	2	100.0	4	100.0	59	100.0
Other physical alterations (OPA)												
None	31	66.0	1	100.0	1	20.0	2	100.0	3	75.0	38	64.4
Adhesions	5	10.6	—	—	—	—	—	—	—	—	5	8.5
Luster	7	14.9	—	—	4	80.0	—	—	1	25.0	12	20.3
Adhesions and luster	4	8.5	—	—	—	—	—	—	—	—	4	6.8
Total	47	100.0	1	100.0	5	100.0	2	100.0	4	100.0	59	100.0

showed some sign of burning (N = 11, 50 percent). This site exhibited more adhesions than any other site (N = 9, 30 percent). Four artifacts (18 percent of surface artifacts) had some burning effects on 76–100 percent of the total portion of the lithic. The top 10 cm of the test pit contained one subsurface lithic artifact that had adhesions and crazing (fig. 33b, table 19).

AR-1931 (Heavy).—AR-1931 had two (33 percent) surface lithic artifacts that exhibited some light sooting, potlids, and medium amount of crazing on 76–100 percent of the total lithic surface (table 20). The one excavated lithic artifact showed no effects of burning. Figure 33c shows a potlid removed from the ventral side of an obsidian artifact.

AR-1886 (Control).—This unburned site had one lithic artifact that exhibited moderate amounts of sooting, potlids, and reduction on 26–50 percent of the artifact surface. Because the site was located outside of the Henry Fire area, this was attributed to an earlier fire.

Discussion.—The lightly burned sites, AR-1961 and AR-2516, exhibited no burn effects on the lithic artifacts. Two sites, AR-2513 and AR-1930, exhibited the most numerous and intensely burned lithic artifacts. The moderately burned site, AR-2513, showed the highest percentage of fire-damaged artifacts (N = 25, 42 percent). This is largely due to the BLA and its long resi-

Table 19—Fire effects on lithic artifacts from AR-1930 (heavy burn).

	Surface		Test pit 1, stratum 1		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion						
No effect	11	50.0	7	87.5	18	60.0
1–25 pct.	3	13.6	—	—	3	10.0
26–50 pct.	3	13.6	—	—	3	10.0
51–75 pct.	1	4.5	1	12.5	2	6.7
76–100 pct.	4	18.2	—	—	4	13.3
Total	22	100.0	8	100.0	30	100.0
Sooting						
None	20	90.9	8	100.0	28	93.3
Light (26–50 pct.)	1	4.5	—	—	1	3.3
Medium (1–25 pct.)	1	4.5	—	—	1	3.3
Total	22	100.0	8	100.0	30	100.0
Potlid						
None	21	95.5	8	100.0	29	96.7
Light (1–25 pct.)	1	4.5	—	—	1	3.3
Total	22	100.0	8	100.0	30	100.0
Oxidation						
None	22	100.0	8	100.0	30	100.0
Total	22	100.0	8	100.0	30	100.0
Reduction						
None	22	100.0	8	100.0	30	100.0
Total	22	100.0	8	100.0	30	100.0
Crazing						
None	17	77.3	7	87.5	24	80.0
Light (26–50 pct.)	1	4.5	1	12.5	2	6.7
Medium (26–50 pct.)	1	4.5	—	—	1	3.3
Medium (76–100 pct.)	1	4.5	—	—	1	3.3
High (26–50 pct.)	2	9.1	—	—	2	6.7
Total	22	100.0	8	100.0	30	100.0
Other physical alterations (OPA)						
None	14	63.6	7	87.5	21	70.0
Adhesions	8	36.4	1	12.5	9	30.0
Total	22	100.0	8	100.0	30	100.0

Table 20—Fire effects on lithic artifacts from AR-1931 (heavy burn).

	Surface		Test pit 1, stratum 1		Total	
	(N)	(pct.)	(N)	(pct.)	(N)	(pct.)
Portion						
No effect	4	66.7	1	100.0	5	71.4
26–50 pct.	1	16.7	—	—	1	14.3
76–100 pct.	1	16.7	—	—	1	14.3
Total	6	100.0	1	100.0	7	100.0
Sooting						
None	5	83.3	1	100.0	6	85.7
Light (26–50 pct.)	1	16.7	—	—	1	14.3
Total	6	100.0	1	100.0	7	100.0
Potlid						
None	21	95.5	8	100.0	29	96.7
Light (1–25 pct.)	1	4.5	—	—	1	3.3
Total	22	100.0	8	100.0	30	100.0
Oxidation						
None	6	100.0	1	100.0	7	100.0
Total	6	100.0	1	100.0	7	100.0
Reduction						
None	6	100.0	1	100.0	7	100.0
Total	6	100.0	1	100.0	7	100.0
Crazing						
None	5	83.3	1	100.0	6	85.7
Medium (76–100 pct.)	1	16.7	—	—	1	14.3
Total	6	100.0	1	100.0	7	100.0
Other physical alterations (OPA)						
None	6	100.0	1	100.0	7	100.0
Total	6	100.0	1	100.0	7	100.0

dence time. Burning was evident to a depth of 10 cm in this area. At AR-2513, a high fire intensity site, high frequencies of adhesions and other burning effects on 76–100 percent of the total lithic surface were present.

Summary of Fire Effects on Lithic Artifacts

Discussion

Of all the lithic artifacts recovered and analyzed, 34 percent (N = 42) were affected by the fire to some degree; the majority were affected on 50 percent or less of their surface. This percentage is not as high as the percentage of fire effects on ceramic artifacts (47.5 percent). This may be attributed to the rate at which soot erodes from porous and nonporous materials. The percentage may have been higher if the artifacts were analyzed immediately after the fire while they still retained their full fire impacts. The expected results from this project would be few damaged artifacts from lightly burned sites and increasingly more damaged artifacts from moderate and heavily burned sites. The first part of this is certain as the lightly burned sites contained lithic artifacts with no burning effects. At moderately burned sites the model becomes more complicated. AR-1905 had two surface artifacts slightly damaged by the fire; the excavated artifact was not damaged. The other moderately burned site, AR-2513, contained the highest number and most intensely charred lithic artifacts of all sites in this project. This is directly related to the presence of a fallen burned log whose residence time severely scorched everything in its immediate vicinity. The two heavily burned sites, AR-1930 and AR-1931, had 40 percent and 39 percent of each total lithic assemblage damaged by fire, respectively. AR-1930 had the highest number of surface lithic artifacts (50 percent) damaged by the fire. AR-1931 had two surface lithic artifacts (33 percent) that exhibited some light sooting, potlids, and moderate amount of crazing. One excavated lithic artifact was unburned.

Implications for Future Studies

Of concern during this study is whether fire effects alter the interpretive potential of the lithic assemblage and prevent recovering information important to prehistory. The results of the lithic artifact study suggest that the interpretive potential of the artifacts analyzed during this phase were compromised through exposure to fire. It must be pointed out, however, that the lithic sample was small, and lithic artifacts were not found in the light burn category. In general, baseline typological/functional categories were not modified to the extent that the information could not be recovered. However, several concerns were identified during the fire effects analysis that have important implications for future studies of lithic artifacts recovered from similar contexts. Based on the observed effects of fire, it was concluded that (in a hypothetical situation) a lithic artifact could be so reduced by fire as to entirely change its function. For example, a core flake could be altered (spalled, cracked) to the extent that it could mistakenly be documented as angular debris. The interpretive implications of such an occurrence are important. It is not believed that the angular debris recorded during the analysis derived from fire-altered core flakes, but the existence of possible areas of ambivalence in future fire studies must be recognized. Likewise, monitoring of oxidation, reduction, sooting, and adhesions on material types during analysis led to the conclusion that severely altered material types may be misidentified, or resist identification because of these attributes. Both adhesions and heavy sooting have the potential for limiting use-wear analysis. Although an untested assumption, it appears plausible that edge damage, because of its typically subtle occurrence (usually monitored microscopically) may be the variable most likely to be overlooked or misidentified under conditions of heavy sooting or adhesions.

The heat treatment of lithic artifacts may be an area with the greatest potential for ambiguity. In the past, raw lithic materials were deliberately subjected to controlled thermal alteration. Presumably, these "heat-treated" artifacts became, after exposure to fire, more amenable to reduction processes. It has not been determined conclusively whether heat treating strengthens raw materials. It became obvious during the course of the analysis that it was not possible to distinguish deliberately heat-treated lithic materials from lithic materials that had been post-occupationally modified by fire. The variables identifying heat treatment are isomorphic. By studying materials unaffected by fire under controlled circumstances, the distinction between heat treatment and fire effects may be resolved. Lithic artifact studies during Phase II should attempt, among other things, to examine the effects of fire-created deposition on edge ware, and develop criteria for isolating morphology related to heat treatment.

ARCHITECTURAL MATERIALS

Adisa Willmer, Office of Archaeological Studies

The masonry structures at all six burned sites were analyzed for the effects of burning on the architectural elements (tuff blocks). The tuff elements of the unburned site (AR-1886) were also monitored so that there was an unburned control sample for comparison. Observations of the lightly, moderately, and heavily burned sites revealed that the tuff elements were affected by fire in four different ways: the rocks were spalled, blackened, reddened, and broken or exploded. A fifth rock alteration, disintegration, was also monitored. This characteristic is thought to be caused by natural erosional processes, and may speed up when the tuff is exposed to heat. Tuff rocks that exhibit crumbling or disintegration were noted at both burned and unburned sites.

Tuffaceous sediments found in the central Jemez Mountains were deposited as the result of volcanic eruptions of hot ash flows in Pleistocene times. Tuff is composed of indurated volcanic ash that has hardened into rock. In the canyon walls where tuff has been exposed, the physical characteristics of the rock range from the topmost layer being quite friable, lower portions indurated but porous, still lower layers slightly or densely welded, and other portions devitrified into finely crystalline aggregate (Ross 1962). The tuff elements used in the small masonry structures found on the archaeological sites are usually partially welded tuffs that are light weight and easily shaped.

Methods

A sample of architectural material was monitored at the six burned sites and one unburned site. A total of 84 tuff building blocks were analyzed, 12 rocks per site. Depending on the density of building blocks present at each structure, a 1-by-1-m to a 5-by-5-m area was monitored. All of the structural materials monitored during the Henry Fire study were tuff building blocks found on the remains of small prehistoric masonry structures (Pueblo IV and V). No other building material was present on the surface of the sites. If a burned log areas (BLA) was present within the structure, the fire-altered elements were monitored during testing. Variables monitored are discussed below.

Spalling

Spalling occurs when fragments have detached from the surface of the tuff element. The effects of spalling were broken down into three categories and were monitored according to the percentage of the rock that was spalled: (1) Lightly spalled: the spalled pieces of rocks were up to 0.99 cm thick; (2) Moderately spalled: the pieces of rock were 1.0 to 3.99 cm thick; and (3) Heavily spalled: the pieces of rock were 4.0 to 9.99 cm thick.

Exploded

Exploded or broken rocks appeared to have been heated to such a high degree that they cracked and separated into two or more pieces. The difference between spalled and exploded tuff blocks is that an exploded rock was fragmented into large pieces (>10 cm) that could be fitted together. Spalled, on the other hand, is when the bulk of the rock is still intact but fragments have detached from the rock's surface. Cracking was monitored and recorded as present or absent.

Blackened and Reddened

The blackened and reddened categories were monitored according to absence or presence. Blackening is probably the result of chemical reduction processes, whereas reddening may be a measure of oxygen intake during a fire.

Disintegration

Disintegration of tuff rocks is the result of natural processes (wind, rain, organisms, as well as fire). Any of these processes can cause the tuff to become friable or eroded, and can contribute to disintegration. Lichen (rock spiraea), for example, is a composite organism (a fungi and a photosynthetic partner) that secretes a substance that helps degrade rock and convert it to soil. Traylor et al. (1990) noted in the La Mesa Fire study that fire probably accelerated these natural weathering processes. The disintegration of building blocks is most likely a progressive occurrence and not solely related to the Henry Fire.

Field Analysis Results

All seven sites consisted of the remains of one- or two-room masonry structures. The structural remains were rubble mounds composed of shaped and unshaped tuff blocks. No other structural materials were visible on the surface of the sites. Provided below are the field data.

Lightly Burned Sites

AR-1961.—This site is characterized as a lightly burned site, and less than 5 percent of the tuff blocks on the surface were affected by the Henry Fire. A 1-by–2-m area was monitored so that a total of 12 tuff rocks could be analyzed (table 21). An area of the structure had a piece of sheet metal on it and the rocks around the metal were lightly spalled and blackened. This comprised the elements that were affected by the Henry Fire. This 1-by-2-m area is not included in the discussion because it is not the normal case for the effects of fire on a lightly burned site. One-third of the rocks monitored in the 1-by–2-m area were in a disintegrated state.

It should be noted that most (58 percent) of the tuff blocks studied at this site had lichen (rock spiraea) growing on them (a green and a black variety). Lichen was not present on the rocks at the other moderately or heavily burned sites. If the lichen had been there, it was probably destroyed by the fire.

AR-2516.—This site is characterized as a lightly burned site and 50 percent of the tuff blocks that are visibly part of the masonry structure were affected by the Henry Fire. Twelve tuff rocks were analyzed in a 1-by–1-m area (table 22). A log burned across the northern portion of the structure and the tuff in the area had been blackened, reddened, exploded, and burned to such an extent that they were very white and friable. This highly burned area was inventoried

Table 21—Fire effects on architectural materials at AR-1961 (light burn).

Rock	Spalled	Exploded	Blackened	Reddened	Disintegrated
1	Not spalled	—	—	—	—
2	Not spalled	—	—	—	—
3	Not spalled	—	—	—	—
4	Not spalled	—	—	—	X
5	Not spalled	—	—	—	—
6	Not spalled	—	—	—	—
7	Not spalled	—	—	—	X
8	Not spalled	—	—	—	X
9	Not spalled	—	—	—	—
10	Not spalled	—	—	—	—
11	Not spalled	—	—	—	—
12	Not spalled	—	—	—	X

X = Present

Table 22—Fire effects on architectural materials at AR-2516 (light burn).

Rock	Spalled	Exploded	Blackened	Reddened	Disintegrated
1	Lightly and moderately, 30 pct.	—	X	—	—
2	Lightly, 5 pct.	—	—	—	—
3	Not spalled	—	—	—	—
4	Not spalled	—	—	—	—
5	Not spalled	—	—	—	X
6	Lightly, 10 pct.	—	—	—	—
7	Not spalled	—	—	—	X
8	Lightly, 30 pct.	—	—	—	—
9	Not spalled	—	—	—	—
10	Not spalled	—	—	—	X
11	Lightly, 60 pct.	—	—	—	—
12	Lightly, 10 pct.	—	—	—	—

X = Present

Table 23—Fire effects on architectural materials at AR-1905 (moderate burn).

Rock	Spalled	Exploded	Blackened	Reddened	Disintegrated
1	Lightly, 60 pct.	—	—	—	—
2	Not spalled	—	—	—	—
3	Lightly and moderately, 10 pct.	—	—	—	—
4	Lightly, 40 pct.	—	—	—	—
5	Not spalled	—	—	—	—
6	Lightly, 60 pct.	—	—	—	—
7	Lightly, 10 pct.	—	—	—	—
8	Lightly, 80 pct.	—	—	—	—
9	Lightly, 60 pct.	—	—	—	—
10	Lightly, 50 pct.	—	—	—	—
11	Lightly, 90 pct.	—	—	—	—
12	Lightly, 20 pct.	—	—	—	—

X = Present

Table 24—Fire effects on architectural materials at AR-2513 (moderate burn).

Rock	Spalled	Exploded	Blackened	Reddened	Disintegrated
1	Moderately and heavily, 50 pct.	X	X	—	—
2	Moderately and heavily, 60 pct.	X	X	—	—
3	Not spalled	—	X	—	—
4	Lightly, 20 pct.	—	X	—	—
5	Lightly, 30 pct.	—	X	—	X
6	Not spalled	X	X	—	—
7	Not spalled	—	X	—	—
8	Lightly, 10 pct.	—	X	—	—
9	Lightly and moderately, 20 pct.	—	X	—	—
10	Lightly and moderately, 80 pct.	—	X	X	—
11	Lightly, 30 pct.	—	X	—	—
12	Moderately, 98 pct.	—	X	—	—

X = Present

separately. One-fourth of the blocks monitored for fire-effects were found to be disintegrated.

Most of the tuff blocks at this site had lichen growing on them (a green and a black variety), and 100 percent of the monitored rocks had lichen present. The presence of lichen appears to be one of the factors that leads to a higher percentage of disintegrated rock at a site.

Moderately Burned Sites

AR-1905.—AR-1905 is classified as a moderately burned site, and 83 percent of the architectural elements found on the surface were affected by the Henry Fire. No lichen was present on any of the building blocks. The area monitored was 1-by-1 m and does not include the area where a log had burned across the structure and caused tuff in the vicinity to be blackened, reddened, and spalled. Table 23 lists the rocks inventoried for fire effects.

AR-2513.—At this moderately burned site, 100 percent of the tuff blocks on the surface of the masonry structure were blackened by the Henry Fire. There is a low density of building blocks on the surface of this site, consequently the tuff blocks monitored came from a 5-by-5-m area so that a total of 12 rocks could be analyzed (table 24). No lichen was observed on the surface of the rocks. A burned log was located along the northwestern portion of the structure.

Heavily Burned Sites

AR-1930.—At this heavily burned site, 83 percent of the tuff masonry elements were affected by the fire. Due to a low density of building blocks on the

surface of this site, a 2-by-2-m area was monitored. No lichen was noted growing on the architectural elements and no burned log was located across the structure. Table 25 lists the rocks inventoried for fire effects.

AR-1931.—AR-1931 has been burned by a high intensity fire. All architectural elements on the surface of the masonry structure were affected. Tuff blocks in a 1-by-1-m area were monitored. A log had burned across the structure and blackened the tuff; these building blocks were not part of the sample monitored. Table 26 lists the rocks inventoried for fire effects.

Control Site

AR-1886 is the unburned control site. On the surface of the structure, 33 percent of the tuff blocks are both disintegrated and lightly spalled. All of the tuff elements have lichen adhering to the surface and it appears that the spalling and disintegration are due to natural erosional processes. None of the rocks exhibit burning characteristics, such as blackening, reddening, or exploding. Twelve tuff elements were monitored in a 1-by-2-m area. Table 27 lists the rocks inventoried for the unburned site.

Discussion

Lightly Burned Sites

AR-1961.—This site showed the least amount of burning on the tuff elements. The only fire-altered attributes were on rocks that were located in the vicinity of a large piece of metal (5 percent of all building blocks). The metal must have retained enough

Table 25—Fire effects on architectural materials at AR-1930 (heavy burn).

Rock	Spalled	Exploded	Blackened	Reddened	Disintegrated
1	Lightly and heavily, 30 pct.	—	X	—	—
2	Not spalled	—	—	—	—
3	Lightly, 60 pct.	—	X	—	—
4	Lightly and heavily, 15 pct.	—	—	—	—
5	Lightly, 30 pct.	—	—	—	—
6	Not spalled	—	—	—	X (60 pct.)
7	Lightly, 20 pct.	—	X	—	—
8	Lightly, 10 pct.	—	—	—	—
9	Lightly and moderately, 40 pct.	—	X	—	—
10	Moderately, 5 pct.	—	X	—	—
11	Moderately and heavily, 60 pct.	X	X	—	—
12	Lightly to moderately, 70 pct.	—	X	—	—

X = Present

Table 26—Fire effects on architectural materials at AR-1931 (heavy burn).

Rock	Spalled	Exploded	Blackened	Reddened	Disintegrated
1	Lightly, 10 pct.	—	X	—	—
2	Not spalled	—	X	—	—
3	Not spalled	X	X	—	—
4	Not spalled	X	X	—	—
5	Heavily, 25 pct.	X	—	—	—
6	Not spalled	—	X	—	—
7	Heavily, 90 pct.	—	X	—	—
8	Heavily, 80 pct.	X	—	—	—
9	Not spalled	X	X	—	—
10	Moderately and heavily, 10 pct.	—	X	—	—
11	Lightly, 80 pct.	—	X	—	—
12	Lightly, 30 pct.	—	X	—	—

X = Present

Table 27—Architectural materials at AR-1886 not affected by the Henry Fire.

Rock	Spalled	Exploded	Blackened	Reddened	Disintegrated
1	Lightly, 20 pct.	—	—	—	X
2	Lightly, 20 pct.	—	—	—	X
3	Not spalled	—	—	—	—
4	Lightly, 30 pct.	—	—	—	X
5	Not spalled	—	—	—	—
6	Not spalled	—	—	—	—
7	Not spalled	—	—	—	—
8	Lightly, 10 pct.	—	—	—	X
9	Not spalled	—	—	—	—
10	Not spalled	—	—	—	—
11	Not spalled	—	—	—	—
12	Not spalled	—	—	—	—

X = Present

heat from the fire to cause the rocks to become blackened and lightly spalled. Lichen was present on 58 percent of the rocks (N = 7). Of these seven rocks, four (33 percent) were beginning to disintegrate. Of the twelve rocks monitored, none exhibited fire effects from the Henry Fire. It is possible that the fire did, however, help to speed up the disintegration of some of the rocks. Lichen was present on 58 percent (N = 7) of the sample.

AR-2516.—Fifty percent of all tuff blocks on the structure were affected by the fire. The fire-altered attributes were minimal when compared to the other sites monitored. Six tuff elements were lightly to moderately spalled (50 percent), and one (8 percent) was blackened by the fire. Between 10 and 30 percent of the rock's surface was spalled (one of the tuff elements had 60 percent of the surface spalled). Lichen was present on all elements analyzed, and three (25 percent) were beginning to disintegrate.

The BLA of the structure exhibited the highest degree of burning on any of the sites. The log had completely burned away, leaving behind a very charred area. Of the tuff in the area, 100 percent was affected. The longer residence time of heat due to the burning log caused at least 30 percent of the rocks to explode. Most of them were also blackened and reddened, and some were heated to such a high temperature that they turned to a white ashy powder.

Moderately Burned Sites

AR-1905.—On this site, 83 percent of the building blocks were fire-altered. The only effects of burning were light to moderate spalling on the tuff elements. Ten blocks (83 percent) were spalled. No other alteration to the rocks was noticed. Six of the rocks had 50 percent of their surface spalled. No lichen was present on any of the building blocks and it is possible that the fire burned the organism.

A log had burned across the north and eastern part of the structure. The rocks in the vicinity of this burned area were heavily spalled. Additionally, the tuff elements were highly blackened and reddened.

AR-2513.—All of the tuff blocks on the structure at this site were affected by the Henry Fire. Nine (75 percent) tuff blocks exhibited some degree of spalling (light, moderate, and heavily spalled). They ranged from having 10 to 98 percent of the surface spalled. All 12 elements (100 percent) were blackened to some degree and 25 percent (N = 3) of the sample were exploded. Only one rock had been reduced to a red color and another was beginning to disintegrate. No lichen was found on any of the rocks.

A partly burned log across the structure caused the tuff elements in the area to become blackened. No other fire effects to the tuff were noted in the log area.

Heavily Burned Sites

AR-1930.—Of the tuff elements on the structure, 83 percent were affected by the fire. Ten (83 percent) exhibited spalling on 20–70 percent of the surface of the rock (spalling ranges from light to heavy). Blackening of the surface of the rock is the next most prominent fire effect (58 percent, N = 7). Only one rock was exploded by the intensity of the fire and one rock shows some disintegration. No lichen is present on the surface of any tuff building blocks. At AR-1931, no log had burned across the structure.

AR-1931.—This site was heavily burned: 100 percent of the architectural material showed fire effects. Blackening of the tuff was found to exist on ten (83

percent) items. Seven (58 percent) rocks were lightly, moderately, or heavily spalled and five (42 percent) were exploded. None of the rocks had lichen attached to them nor were any disintegrated.

A log had partly burned across the structure at AR-1931. The rocks in the vicinity of the burned log had been blackened. No other fire effects occurred.

Control Site

AR-1886 was not burned during the Henry Fire in 1991. Even though this site was not subjected to the most recent fire it probably has been exposed to many fires that have occurred in the area since prehistoric times. AR-1886 exhibited minimal amounts of spalling and disintegration similar to that found on the lightly burned sites (AR-1961 and AR-2516). Thirty-three percent of the rocks were lightly spalled and 33 percent were beginning to disintegrate. No other attributes were noted except that all of the tuff blocks had lichen adhering to their surface.

Summary of Fire Effects on Architectural Material

Discussion

The analysis of tuff building blocks at the burned sites showed that 69 percent of the rocks were fire-altered. Moderately and heavily burned sites had 83–100 percent of their building blocks affected by the fire, while lightly burned sites exhibited from 0 to 50 percent fire damage. The degree of impact that the Henry Fire had on the tuff blocks is related to fire intensity, if there were logs or branches that burned across the structure (fire residence time), and if other heat conducting material was near the structure.

Spalling of tuff elements is the most obvious and pervasive attribute. Heavily and moderately burned sites exhibited a higher percentage (59–83 percent) of spalled rocks than lightly burned sites (0–50 percent). The spalling on the heavily burned sites was also located over a larger surface area of the rock. Spalling of tuff building blocks appears to be an indicator that a fire (or fires) has impacted an archaeological site. Spalling on the control site AR-1886 may mean that this site had been exposed to previous forest fires that swept across Holiday Mesa, or it may be part of the natural erosion process.

Since it has been predicted that fires occur every 5 to 7 years, spalling alone is not a good measure of the severity of the fire or when the fire occurred. In the sample, a high degree of spalling along with exploded rock and blackening are representative of what a moderate to high intensity fire can do to tuff building elements. Exploded or cracked tuff is a very good indicator that the rock was exposed to a "hot" fire, such as the Henry Fire. Only on three of the sites was cracking found and this was on moderately and heavily burned sites (AR-2513, AR-1931, and AR-1930). More often than not, the rocks that were cracked or exploded were also blackened by the intense fire. However, it should be noted that all exploded rocks exhibited spalling. It is probable that when tuff is heated at high temperatures, the surface and interior of the rock are exposed to similar effects and crack instead of spall. Spalling may be the result of the exterior of the rock being subjected to heat, causing the outside of the rock to expand and flake while the interior of the rock remains cool and intact. Blackening appears on all categories of burned sites and covered from 58 to 100 percent of rock surfaces at AR-2513, AR-1930, and AR-1931 (moderately and heavily burned sites). Blackened rocks were not found on AR-1905, a moderately burned site. At AR-2516, a lightly burned site, only one tuff element was blackened. The reason that the tuff rocks are reduced may be related to the amount of litter that is present on the site. Blackening may be the result of a thicker bed of needles and branches that covered the structure, and when they burned they released smoke that blackened the tuff.

Disintegration of the tuff blocks occurred on all types of burned sites as well as the unburned control site. The sites with the higher percentage of disintegration are also sites that had lichen present on the rock. The lightly burned sites (AR-1961 and AR-2516) had more than 50 percent of the tuff with lichen; 25–33 percent of this sample exhibited disintegration. On the control site, with 100 percent of the tuff covered with lichen, 33 percent of the tuff was disintegrating. The presence of lichen appears to be one of the factors that leads to a higher percentage of disintegrated rock at a site. There was one rock each from a moderately and heavily burned site that was beginning to disintegrate that may or may not have had lichen prior to the Henry Fire.

In conclusion, heat caused by the Henry Fire affected tuff elements found on structures at archaeological sites. As expected, tuff building blocks at moderately and heavily burned sites were damaged to a higher degree than at lightly burned sites. The sites that had logs burned across the structures gen-

erated enough heat that the tuff was always damaged to a high degree. Over time and after the many fires that have occurred, tuff begins to undergo chemical and physical alterations. Since there is enough heat generated at moderately burned sites to significantly alter the tuff (83–100 percent affected), the threshold when significant physical and chemical changes begin is somewhere between light and moderate intensities.

During the La Mesa Fire study, it was observed at heavily burned sites that blackened, spalled tuff blocks appeared whole and strong. When lifted, however, they could not hold together and snapped in two or crumbled (Traylor et al. 1990). This leads to the question of the long-term effects that fire may have on building material. In this study, moderate and heavily burned sites had similar proportions of damage to the tuff building blocks and at these sites the tuff may be permanently altered, leaving the site susceptible to increased erosion.

Implications for Future Studies

Phase I architectural studies suggest that attrition to tuff building elements caused by exposure to fire contributes to the deterioration of the site. Tuff, in particular, tends to be more susceptible to erosion induced by fire. This has important implications for overall integrity and condition/preservation status of the site. Disintegration of the tuff elements due to exposure to fire may accelerate the natural processes of erosion and attrition caused by snow, rain, wind, and other natural phenomena. Also, fire consumes any wooden structural elements that might be present, such as vigas, latillas, and jacal walls. Although findings on this subject were inconclusive during Phase I studies, the potential for complete deterioration of the site was recognized. Cumulative effects of fire and erosion processes could conceivably obscure the diagnostic capabilities of the site. Deterioration of wall alignments could obscure the ability to determine the type or age of the feature and the number of components present. A totally reduced structure with few artifacts may come to resemble a natural occurrence, such as a rock outcrop. The implications of advanced site deterioration brought on by fire may have important implications for site interpretation.

Phase II research on structural elements will focus on the effect of a single episode controlled burn on a variety of indigenous materials used in prehistoric construction. It is expected that this experiment will provide information that will help build a model to predict the rate of deterioration of small structural sites.

OBSIDIAN HYDRATION

Tom Origer, Sonoma State University

Past fire studies have shown that fire has a measurable effect on the hydration rind that forms on obsidian artifacts (Trembour 1990). Areas of concern in the Henry Fire study are: To what degree do different fire intensities damage the hydration rind? And, will this damage obscure the possible dating of the artifact? Ten samples of obsidian collected from surface and subsurface contexts were sent to the Obsidian Hydration Laboratory at Sonoma State University. Thomas M. Origer, the director of the laboratory, was also the technician that conducted the analysis on the obsidian samples.

Results of Hydration Band Measurements

This section reports the hydration band measurements obtained from ten obsidian thin-sections from the Henry Fire study (table 28). The specimens were examined under the microscope in the order listed, not according to the burn condition. This was done to eliminate potential bias. In addition to making hydration band measurements, each specimen was micro- and macroscopically examined for signs of fire-alteration. This work was completed as requested by the Office of Archaeological Studies (OAS). The analysis was completed at the Sonoma State University Obsidian Hydration Laboratory, an adjunct of the Anthropological Studies Center, Department of Anthropology. Procedures used by the hydration lab for thin-section preparation and hydration band measurements are described below.

Table 28—Obsidian artifacts submitted for hydration analysis.

Lab Number	Artifact Type	Source
1	Core flake	AR-2516, F.S. 4, 96N/105E, Surface; site was lightly burned
2	Core flake	AR-1886, F.S. 22, 94N/112E, Surface; unburned control site
3	Angular debris	AR-1961, F.S. 33, 81N/103E, Surface; site was lightly burned
4	Core flake	AR-2513, F.S. 34, 103N/80E, Surface; site was moderately burned
5	Core flake	AR-1931, F.S. 35a, 84N/104E, Surface; site was heavily burned
6	Projectile point	AR-1961, F.S. 35b, Test pit 1, Stratum 1; site was lightly burned
7	Core flake	AR-1930, F.S. 51, 93N/102E, Surface; site was heavily burned
8	Multidirectional core	AR-1905, F.S. 62, 95N/105E, Surface; site was moderately burned
9	Core flake	AR-1905, F.S. 86, Test Pit 1, Stratum 1; site was moderately burned
10	Angular debris	AR-1930, F.S. 114, Test Pit 1, Stratum 1; site was heavily burned

Each specimen was examined in order to find two or more surfaces that would yield edges perpendicular to the microslide when preparation of the thin-section was completed. Two small parallel cuts were made at an appropriate location along the edge of each specimen with a 4-inch diameter circular saw blade mounted on a lapidary trimsaw. The cuts resulted in the isolation of a small sample with a thickness of approximately 1 mm. Each sample was removed from its specimen and mounted with Lakeside Cement onto a permanently etched petrographic microslide.

The thickness of the samples was reduced by manually grinding with a slurry of #500 silicon carbide abrasive on a glass plate. The grinding was completed in two steps. The first grinding was terminated when the sample's thickness was reduced by approximately one-half, thus eliminating any microchips created by the saw blade during the cutting process. The slides were then reheated, which liquified the Lakeside Cement, and the samples inverted. The newly exposed surfaces were then ground until the proper thickness was attained.

The correct thin-section thickness was determined by the "touch" technique. A finger was rubbed across the slide, into the sample, and the difference in thickness between the slide and the sample was "felt." The second technique employed for arriving at a proper thin-section thickness is termed the "transparency" test. The microslide was held up to a strong source of light and the translucency of the thin-section was observed. The sample was sufficiently reduced in thickness when the thin-section readily allowed the passage of light.

A protective coverslip was affixed over the thin-section when all grinding was complete. The completed microslides are curated at the hydration lab under File No. 92-H1145.

The hydration bands were measured with a strain-free 40X objective and a Bausch and Lomb 12.5X filar micrometer eyepiece on a Nikon petrographic microscope. Six measurements were taken at several locations along the edge of the thin-section. The mean of the measurements was calculated and listed in table 29 with other information. These hydration measurements have a range of ± 0.2 due to the normal limitations of the equipment.

In addition to analyzing hydration, notes were made about each thin-section's micro- and macroscopic condition. Next, their macroscopic condition was studied. The notes are listed in table 30.

Based on information presented in tables 29 and 30, some conclusions can be stated regarding the effect that burning had on hydration bands found on obsidian specimens used in the Henry Fire study. Lightly burned specimens showed no effect of fire, either on a micro- or macroscopic level, and they were marked by measurable hydration bands. Those from moderately burned conditions showed slight to moderate microscopic damage, but no obvious macroscopic alteration. Two of the three moderately burned items yielded good hydration band measurements; however, one specimen's hydration was diffuse. It is pointed out here that it is not known whether moderate burning created hydration that was diffuse; it may have been altered prior to burning. Lastly, two of the heavily burned specimens appeared altered and one did not. Again, the condition of these specimens prior to burning is unknown.

Although the number of analyzed specimens is small, some general statements can be presented. It appears that light burning had minimally affected the condition of hydration bands. The moderately burned specimens yielded measurable hydration bands in two of three (66 percent). In contrast, heavily burned specimens were marked by damaged hydration in 66 percent of the cases. It seems clear that the heavier the degree of burning, the greater the adverse effect to the hydration band.

Table 29—Hydration band measurements.

Source	Burn intensity	Sample number	Measurements (microns)	Mean thickness (microns)
AR-1961, F.S. 33, Surface	Light	3	2.3, 2.3, 2.4, 2.4, 2.4, 2.5	2.4
AR-1961, F.S. 35b, Stratum 1	Light	6	6.0, 6.0, 6.1, 6.2, 6.2, 6.3	6.1
AR-2516, F.S. 4, Surface	Light	1	1.8, 1.8, 1.8, 1.8, 1.9, 1.9	1.8
AR-1905, F.S. 62, Surface	Moderate	8	Diffuse, approximately 2.9	
AR-1905, F.S. 86, Stratum 1	Moderate	9	2.0, 2.1, 2.1, 2.3, 2.3, 2.3	2.2
AR-2513, F.S. 34, Surface	Moderate	4	1.4, 1.4, 1.4, l.4, 1.6, 1.6	1.5
AR-1930, F.S. 51, Surface	Heavy	7	2.4, 2.4, 2.5, 2.6, 2.6, 2.6	2.5
AR-1930, F.S. 114, Stratum 1	Heavy	10	Diffuse	
AR-1931, F.S. 35a, Surface	Heavy	5	No visible hydration ban	
AR-1886, F.S. 22, Surface	Control	2	No visible hydration band	

Table 30—Condition of obsidian specimens.

Source	Burn Intensity	Sample number	Macroscopic condition	Microscopic condition
AR-1961, F.S. 33, Surface	Light	3	Good surfaces	Good surfaces
AR-1961, F.S. 35b, Stratum 1	Light	6	Good surfaces	Good surfaces
AR-2516, F.S. 4, Surface	Light	1	Good surfaces, shiny, undamaged	Good surfaces
AR-1905, F.S. 62, Surface	Moderate	8	Good surfaces	Slightly damaged surfaces
AR-1905, F.S. 86, Stratum 1	Moderate	9	Good surfaces	Moderately damaged surface
AR-2513, F.S. 34, Surface	Moderate	4	Good surfaces	Slightly damaged surface
AR-1930, F.S. 51, Surface	Heavy	7	Dull dorsal, good ventral	Damaged surfaces, one more so
AR-1930, F.S. 114, Stratum 1	Heavy	10	Good surfaces	No obvious damage
AR-1931, F.S. 35a, Surface	Heavy	5	Good dorsal, dull ventral	Damaged surfaces, one more so
AR-1886, F.S. 22, Surface	Control	2	Dull damaged surfaces	Damaged surfaces

Replication of the experiment would be a next logical step with a larger number of specimens analyzed under carefully controlled conditions where temperatures are recorded and the duration of burning determined.

In conclusion, the results of this study suggest that burning adversely affects hydration; therefore, the research value of obsidian artifacts and archaeological sites could be reduced.

Conclusions of Fire Effects on Obsidian Artifacts

The above results show that burning of obsidian artifacts does affect hydration of these items. Without a preburn comparative sample of the artifacts taken before the Henry Fire occurred, however, it is not known how much damage was a result of heat generated from this specific fire. The cause of the damage on the surfaces of the obsidian items is unknown. This analysis does show that these items were burned and hydration bands were affected by the Henry Fire, but the other surface damage listed in table 30 may not necessarily have been fire induced. Data between surface and subsurface contexts are inconclusive because of the small sample that was analyzed.

Obsidian artifacts from heavily burned sites were affected to a greater degree than moderately and lightly burned sites. Damage to the hydration band (diffusion) was only noted on obsidian items from both AR-1930 and AR-1931 (heavily burned sites). Measurable hydration bands still existed from the lightly and moderately burned sites, with one of the three samples from the moderately burned sites having a diffused band. The cause of diffusion to the hydration band cannot be determined, but the presence of burning on obsidian samples from the Henry Fire study is conclusive.

In Phase II of this project, it will be necessary to use obsidian samples that can be analyzed before and after the prescribed burns so that there is a direct correlation between burning and the damage it causes on obsidian artifacts. It is also predicted that the hotter the fire and the longer the residence time, the greater the effect on the hydration measurement. Consequently, it will be important to control the conditions of the prescribed burning of Phase II so that temperature and residency time can be recorded. Also to be addressed during Phase II are the effects of fire on surface and subsurface obsidian artifacts, and a comparison between the two data sets. It is currently thought that absolute dates for archaeological sites may not be obtainable through obsidian hydration techniques; however, relative chronological frameworks can be established through comparison of the obsidian hydration data with existing chronometric curves. These data will be useful in considering site chronology, as well as providing a measure of fire effects on obsidian artifacts.

PHASE I CONCLUSIONS

Stephen C. Lentz, Office of Archaeological Studies

The research framework developed for Phase I of the Jemez study of the Henry burn includes preliminary models designed to objectively assess and measure the effects of fire on cultural resources, evaluate the effects of fire of varying intensities on a range of cultural materials through laboratory analyses, determine the thresholds at which fire damage occurs on cultural materials and sites, predict the anticipated effects of damage so that cultural resources can be protected, and determine the point at which the dating potential of a site is compromised through exposure to fire. These studies comply with Section 106 of the NHPA, 36 CFA 800 (Criterion D) and other pertinent state and federal regulations. The analytical results by site in relation to the research framework are addressed in this section.

The Phase I archaeological program included limited testing on seven sites, a functional/typological and specialized artifact analysis, and an architectural analysis. Preliminary findings indicate that fire can thermally alter *all* artifact types. Figure 34 demonstrates a regular relationship between the severity of the burn and the degree of fire effects (obsidian samples were subjected to a different analysis process, and is omitted on the graph, fig. 34). Although past fire studies have shown that fire is detrimental to artifacts, the OAS/USFS preliminary findings suggest that even low intensity burns (such as the USFS prescribes) have some degree of negative result (see Discussion and Recommendations at the conclusion of this section). Kelly and Mayberry (1969:5), for example, have stated that their limited research seemed to verify that lower combustion levels did not affect cultural materials significantly but may affect site environments more seriously. They argued that it seemed clear that high-temperature intense combustion produces destructive impacts along with many fire control methods. In contrast, the OAS results show that lower combustion levels do, in fact, produce measurable fire effects.

To briefly summarize some of the preliminary findings presented below, the Phase I analysis indicates that the least affected artifact type was ground stone. Sooting was the dominant fire effect category overall. Fire effects were present even on lightly burned sites, and the effects increased significantly on moderate and heavily burned sites. In some instances, the diagnostic potential of ceramic artifacts and the chronometric potential of obsidian samples were compromised. Perhaps because of their physical constituents, sherds are more apt to exhibit fire damage than lithic or ground-stone artifacts. Tuff building blocks at moderately and heavily burned sites were damaged more than at lightly burned sites. This suggests that the effects of fire are not limited to artifacts, but may also affect the structural components of a site. Unfortunately, no nonarchitectural features (such as hearths or pits) were present within the investigated sample of sites, and therefore could not be evaluated with respect to the research framework. Meanwhile, the indication that fire effects are exacerbated by burning logs, branches, or stumps located within the site limits is potentially important information with far-reaching implications. The consequences of residence time are discussed in greater detail below.

Lightly Burned Sites: AR-1961 and AR-2516

On lightly burned sites, no effects were noted on the small sample of lithic artifacts recovered from AR-1961 and AR-2516. The ceramic artifacts were lightly sooted except for AR-1961, where there were severe fire effects on sherds recovered from a BLA. On AR-1961, ground-stone items were sooted, and architectural elements were spalled. Lithic and ceramic subsurface artifacts were unburned the chronometric potential of obsidian artifacts was comprised. This suggests that there are minimal effects on sites that have been lightly burned unless there is a log, branch, or stump present.

Moderately Burned Sites: AR-1905 and AR-2513

On moderately burned sites (AR-1905 and AR-2513) ceramic and lithic artifacts registered appreciable amounts of fire effects, particularly on surface artifacts, where nearly 75 percent of the surface ceramic artifacts at AR-2513 were affected. No ground-stone artifacts were recovered from sites in the moderate burn category. Architectural elements were blackened and spalled at AR-1905, and heavily spalled in the vicinity of a BLA. Artifacts recovered from excavations at AR-1905 showed no signs of fire effects. At AR-2513, all of the rubble associated with

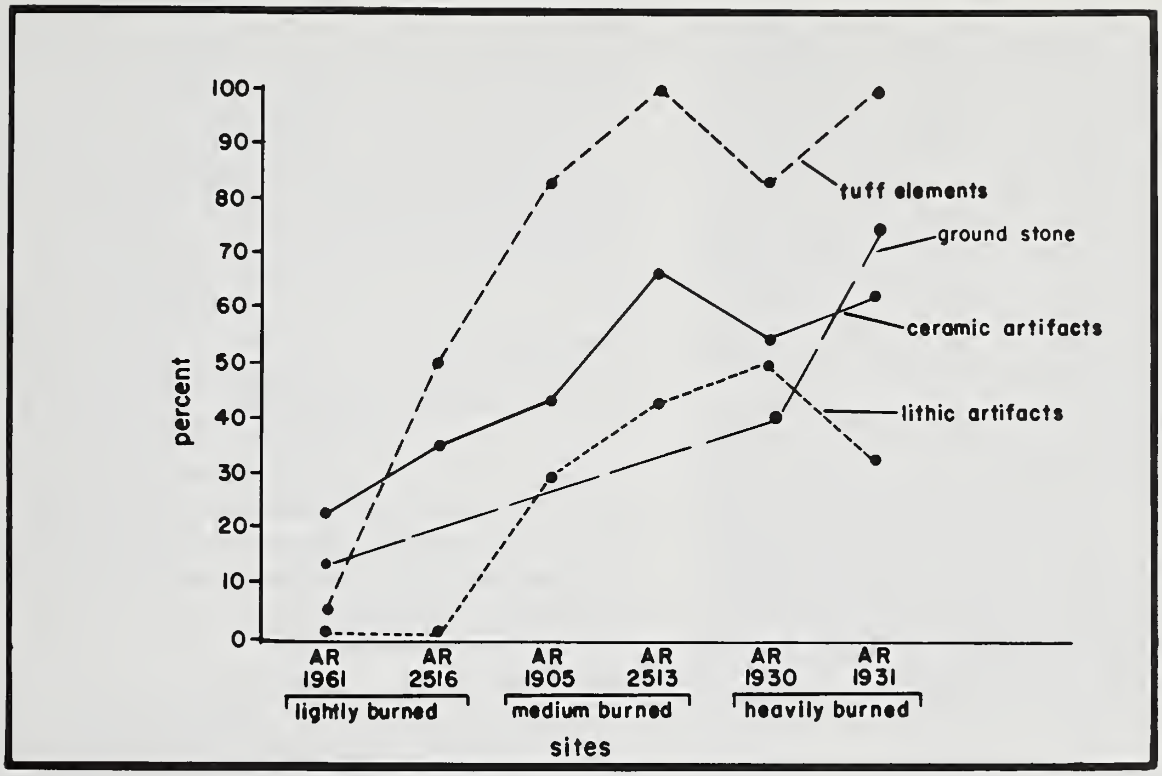

Figure 34—Percent of burning on cultural material by site.

the fieldhouse was spalled. There was also spalling of architectural elements located during test excavations. Ceramic and lithic artifacts were severely affected to a depth of at least 10 cm in Test Pit 1, AR-2513. At this site, surface and subsurface fire effects on architectural elements and lithic and ceramic artifacts were due to a BLA residing on the architectural component of the site. This suggests that artifacts and features on moderately burned sites will sustain moderate fire effects unless there is increased residence time brought on by fuel loads burning in situ.

Heavily Burned Sites: AR-1930 and AR-1931

Severe fire effects were present on artifacts, construction materials, and ground stone from sites in the heavily burned category, AR-1930 and AR-1931. No subsurface fire effects were recorded on the artifacts from the test excavation at AR-1930, probably because there was no BLA; however, nearly 30 percent of the subsurface ceramic artifacts recovered from excavations at AR-1931 were burned. These were recovered from a BLA located on the structural component of the site.

These data illustrate the proposition that where there are no fuels burning in place, fire effects may be confined to the surface. Where there is increased residence time because of a log or other types of fuel loads (as in the case of AR-1961, AR-2513, and AR-1931), subsurface artifacts can be severely affected. It is worthwhile noting that these sites come from light (AR-1961), moderate (AR-2513), and heavy (AR-1931) burn areas.

Data Loss

Site condition and preservation status are directly relevant to the Section 106 process of the National Historic Preservation Act and Executive Order 11593 (criteria for assessment of modern disturbance, *National Register Bulletin* 16A 1991:32) and the legal framework of 36 CFR 800 (Criterion D: "properties may be eligible for the National Register of Historic Places if they have yielded, or are likely to yield, information important in prehistory or history," *National Register Bulletin* 15 n.d.:21). One of the primary purposes of this study was to determine the degree to which burning of archaeological sites inhibits ac-

curate evaluation of data potential with respect to the Section 106 process. The inherent limitations of the data set during this project make it difficult to impose absolute measures of actual or potential data loss without to speculation. However, some estimates of data loss are suggested by the preliminary findings. At the very onset, it must be assumed that systematic exposure to fire does little to enhance site condition. It may never be known what degree of data loss (perishable materials, temporary structures, surface artifacts) these sites have already experienced through time. There is a need to develop objective measures to classify data loss in the face of these unknown quantities. To do this, predictive models, experimental situations, and site and artifact reconstructions are proposed in the following section. Findings and potential fire effects on individual artifact classes are discussed in their respective sections. Despite the preliminary nature of the Phase I results, some limited inferences may be possible.

Ceramic Artifacts

This data class has the greatest potential for yielding information on fire effects. Pottery is sensitive to fire. For this experiment, modern versions of prehistoric pottery can be replicated. Based on empirical evidence, it was recognized that the potential for error in ceramic identification is much greater during in-field analysis than under laboratory conditions. These conclusions were derived from an actual experience during Phase I where misclassification of diagnostic materials occurred. Having empirical evidence of compromised diagnostic materials allowed the data to be tested and quantified with some degree of probability. At site AR-1961 (see the ceramic section earlier in this report) misidentification of ceramic artifacts in the field was reconciled during laboratory analysis. Under the fire conditions at this site (light burn), the typological misclassification was the result of the combined effects of color-altered pigment, vitrification, and crackling. At this site, it was estimated the probability for misinterpreting ceramic data *in the field* is approximately 40 percent. This figure was calculated from the frequency of Jemez Black-on-white sherds showing demonstrable fire effects at AR-1961 (N=4).[2] Artifacts were collected from the surface in the vicinity of a BLA. (This evaluation assumes that the archaeologist has limited knowledge of the past condition of the site.)

The loss of a critical design element from spalling would substantially reduce the potential for in-field identification of a ceramic artifact. Likewise, heavy sooting could prevent the initial recognition and documentation of a pottery type in the field. Uncertainty as to the life span of sooting (whether it constitutes a temporary condition or is a permanent or cumulative condition) prevented estimates as to possible data loss and will be tested during Phase II.

Finally, it was noted that under microscopic examination, petrographic attributes suffered from exposure to excessive heat through color alteration and vitrification. Again, a numeric value cannot be assigned to these attributes until preexisting circumstances are established.

Lithic Artifacts

No actual difficulties were encountered in the field or during analysis with the typological/ functional inventory of lithic artifacts. However, several areas of potential error were identified. These occurred within the categories of heat treatment, debitage type, material type, and edge-wear morphology. The lithic analysis section concludes with several hypothetical situations in which fire effects could contribute to erroneous data retrieval and subsequent management recommendations based on those data. During laboratory analysis, it became apparent that deliberately heat-treated lithic materials and lithic materials that had been post-occupationally modified by fire were, in some instances, indistinguishable. It was suggested that heat treatment of lithic artifacts may be an area with the greatest potential for misidentification, particularly in the Jemez Mountains, where volcanic activity has already substantially altered chert sources. In the area of flake morphology, a core flake heavily cracked and spalled by fire could be mistakenly documented as angular debris. Also, a lithic artifact could be so reduced by fire as to entirely change its function or material type. Potlids forcibly removed from a lithic artifact due to fire effects could be misinterpreted as the result of a heat treating. Damage to ventral, dorsal, or marginal morphology could occur. Excessive adhesions on a utilized edge could prevent accurate in-field analysis and identification of the activity performed by that artifact (although these determinations are usually made during laboratory analysis). Sooting covering

[2] *Caution should be used in interpreting these results, which apply to one site only. These data do not represent overall fire effects on archaeological sites from the Henry Fire study.*

the surface of a lithic artifact would limit an archaeologist's ability to recognize material type, morphology, or condition of the artifact. However, since these areas were speculative, no absolute measures of potential data loss could be generated. Experimental artifacts will be prepared during Phase II that may provide some answers to these questions.

Ground-Stone Artifacts

The ground-stone sample was too small to be able to reach any substantive conclusions. Fire effects on these items will be tested during Phase II.

Architectural Elements

Preliminary data show that the tuffaceous elements, which typically comprise fieldhouse architecture, are systematically damaged by fire. The percentage of data loss on structural elements cannot be inferred without knowing the preexisting baseline condition of the site prior to the fire. Closing materials, usually composed of dry wooden elements *(vigas* and *latillas)*, are particularly susceptible to fire. They may also provide chronometric information (see above). Based on these data, several predictions can be made and tested during Phase II.

Chronometric Samples

Although the utility of using rind measurements on obsidian artifacts as a means of achieving temporal control is controversial, these is a consensus (based on data from these and other studies) that the chronometric potential of obsidian artifacts is directly compromised through exposure to fire.

Both tree-ring and radiocarbon specimens are organic and therefore combustible. Research potential could be reduced or negated through exposure to fire. It should be noted, however, that tree-ring and C–14 samples are usually recovered from hearth features or roof fall. In Pueblo-phase structures, these features may be protected by the cultural and natural soil. The affect on archaeomagnetic samples[3] is unknown, but there is a high probability that sustained heat produces negative results. This proposition will be tested during Phase II.

Discussion and Recommendations

The objectives of this study were to (1) determine whether cultural resources were negatively affected by prescribed burns or wildfire, (2) determine the degree to which data loss occurs, and (3) make management recommendations (table 31). The following conclusions are tentative, based on limited information, and are intended to be used discriminately.

Phase I archaeological research suggests that fire effects are present on artifacts under all burn categories, but that fuel loading is the critical variable in the severity of these effects. Preliminary findings suggest that impact to cultural resources can be held to a minimum by removing extraneous fuel loads from the surface of the site prior to prescribed burning. This will avert the effects caused by prolonged residence time of burning surface materials on both surface and subsurface artifacts.

During Phase I, OAS was unable to address a portion of the research design, which included developing a set of techniques for objectively measuring temperature, fire-line intensity, and other fire characteristics (questions 1 and 4). During Phase II, actual temperatures and fire-line intensities can be monitored during controlled burn episodes, possibly through the use of specialized equipment. Earlier, we cautioned that the terms "fire effects" and "damage" are not synonymous. In the absence of rigorous criteria, notably the lack of a comparative framework, a definition of damage (permanent or temporary) was not used. Data from Phase II may provide the information needed to develop a working definition of what constitutes negative a fire effect (i.e., damage) to a site, artifact, feature, or chronometric sample.

Pronouncements about the effects of burning on archaeological sites should be avoided until further research is completed. However, the results of the artifact analysis suggest that even under conditions of light burning, the integrity of cultural resources within a burn area is significantly altered, and substantial effects are present at moderate and high intensities. Subsurface thermal alteration to artifacts can occur, under certain conditions, to a depth of at least 20 cm. Fuel loading was identified as an important cause of damage to artifacts. Since there appears to be a predictable pattern to the burning—cultural resources sustain effects in direct proportion to the severity of the burning—this knowledge may be useful in future studies. The USFS usually implements prescribed burns at low intensities; therefore, it is important to recognize to what degree cultural resources are affected by these activities. If fuel loading were appropriately managed, however, the effects could be minimized. Prudent management may include a

[3] *Archaeomagnetic dating is a method of dating cultural contexts that have been baked (such as clay heath, or burned soil) by measuring the magnetic particles in a sample in relation to the change in the earth's magnetic field.*

comprehensive inventory of all cultural resources within a prescribed area, and preventative actions (such as removing fuel loads) taken. Since wildfire is impossible to predict, it may be necessary to inventory cultural resources in areas where wildfires are most likely to occur, in anticipation of episodes like the Henry Fire.

It is not known, nor will it be known until further research is done, how many of the observed fire effects are the result of past fires, and how much can be attributed to prescribed burning by the USFS or wildfire. The question of burning (whether intentional or resulting from natural phenomena) and possible impact on cultural resources has important management and legal implications. The goal of no effect on cultural resources is optimal, not only for compliance with existing state and federal regulations, but to better understand and manage cultural resources in the national forests. Preliminary observations suggest that there may be legitimate concerns regarding integrity and condition/preservation status of sites that have been exposed to controlled burns or wildfire. The assumption has been that the sites have been burned numerous times in the past, and that low intensity controlled burns do not create additional disturbance. Data from this study show that

Table 31—Findings and recommendations for Phase I.

Problem area	Phase I findings	Recommendations
Cultural resources negatively affected by repeated exposure to USFS prescribed burnings or wildfire	Substantial fire effects were recorded on artifacts under all fire intensities. Damage to artifacts can occur up to 20 cm subsurface. The most damage occurred in the BLA areas. Fuel loading is the critical variable in the severity of these effects. Unable to objectively measure temperature, fire line intensity, and other fire characteristics.	Set zero effects as goal. Increase cultural resource inventories. Manage fuel loading on sites. Develop independent fire measurements. Monitor fire effects on sites with documented quantities of fuel loading.
Under what conditions, to what	Without a comparative framework, degree, and in what proportion are artifacts affected (Section 106, 36 CFR 800 concerns).	Further research using controlled only limited inferences can be made. experiments. Determinations from current findings are applicable to survey data only.
The effects of fire on overall site condition	Overall effects appear to be negative, especially on site architecture; however, extent of effects is unknown.	Construct facsimile site.
Chronometric samples	Dating potential of obsidian rind measurements is affected by fire; tree-ring, C–14, and archaeomagnetic samples are susceptible to burn damage.	Experiments with previously measured rinds (see Phase II Research Design). In some cases, tree-ring and C–14 samples may be protected under structural fill.
Fieldhouse architecture	Tuff blocks were severely eroded by fire and heat; roof elements burned.	Construct experimental site (see Phase II Research Design).
Fire effects on ceramic artifacts	40 pct. of surface ceramic artifacts at AR-1961 (a lightly burned site) were misclassified.	Experiment on recently manufactured and prehistoric ceramic types (see Phase II Research Design).
Fire effects on lithic artifacts	Few effects recorded; potential effects are high, especially for data categories of heat treatment, material type identification, artifact type identification, and edge wear.	Monitor effects on a series of recently manufactured and prehistoric lithic artifacts.
Fire effects on ground-stone artifacts	Unknown; sample was too small.	Place ground stone at experimental sites.

there may, in fact, be evidence to the contrary. If prescribed burns disturb cultural resources, it is important to identify its causes, and develop a set of independent measures to be able to discriminate between past burns and prescribed burns.

Because of the amount of unknown variables, measurable data loss with regard to Section 106 and 36 CFR 800 was only possible with obsidian hydration data and a small sample of ceramic artifacts. It is likely, however, that the overall integrity of a site (particularly tuff-built, Jemez-style fieldhouses) suffers severe attrition from fires of the intensity of the Henry Fire. The majority of state and federal cultural resource determinations are made at the nonintensive survey level. The combined data from Phases I and II should provide some guidelines with which to evaluate data loss. While the findings may be more relevant to survey data, information from Phase II may determine the level of analysis at which these data are the most substantive.

The data from Phase I of the Jemez Fire Study on the Henry burn data show that fire effects on certain categories of artifacts have the potential of seriously diminishing the ability of these cultural resources to contribute information important to prehistory. The numeric extent of these effects can only be partly measured at this time, and only limited inferences can be made without further research. It is suggested that the adverse effects would be partly reduced through fire management techniques. Phase I is intended to provide preliminary information on the effects of fire on cultural resources, and is lacking a comparative framework. Controlled experiments on cultural resources that have not sustained damage from past fires may provide the information required to make informed decisions concerning cultural resources and fire effects.

PHASE II RESEARCH DESIGN

Stephen C. Lentz, Office of Archaeological Studies

A set of research questions were proposed and partially addressed during Phase I of this project. These questions were developed to understand the effects of fire on cultural resources and to make use of that understanding to better protect cultural resources in wildfire and prescribed burn situations (see Research Framework).

As discussed in the conclusions section of Phase I (above), this preliminary study was able to address the research questions that (1) did not require knowledge of past fire effects, and (2) did not require experimental situations (reserved for Phase II). Questions 2 and 7 (effects criteria, changes to artifact data resulting from fire) were addressed in a preliminary fashion, with nonrigorous criteria applied to fire effects artifact analysis. Questions 1 and 4 (measuring techniques, fire thresholds) will be addressed during Phase II, and questions 5 and 6 (predicting, protecting) were partially answered.

Controlled Field Experiments

Based on the results of Phase I data analysis and interpretation, the following field procedures and experiments are recommended:

1. Conduct prescribed burning across a sample of selected prehistoric sites and experimental sites under conditions of light, moderate, and heavy fuel loading in each of the 6 fuel models, for a total of 12 experiments.
2. Because of the frequency of burning within the following fuel models, the USFS has requested that the fuel models be prioritized in the following order: Fuel Model 11, followed in succession with Models 9, 4, 5, 2, and 10 (see descriptions of fuel models at beginning of report).
3. If cultural resource sites sustain measurable fire impact under conditions of light or moderate fuel loading within a particular fuel model, there is no need to experiment with other fuel loading conditions. If no damage is recorded under conditions of light *and* moderate fuel loading, then
4. Conduct further experiments under conditions of heavy fuel loading, following the fuel model sequence described above. Continuing the experiment with higher fuel loads could provide estimates of damage related to fuel loading.
5. Analyze results to determine the effects of a range of fire types and burn intensities on various classes of cultural resources and materials and assess whether or not the effects are significant in terms of loss of integrity, and research potential.
6. Develop a reliable means to predict the effects of fire on cultural resources based on fuel characteristics, nature of cultural resources, and other variables that will be developed based on empirical observations during the experiment.
7. Determine appropriate thresholds or a set of criteria to define the upper temperature limits at which prescribed fires can be conducted with minimal threat to cultural resources. Since prescribed burns usually occur under conditions of low and moderate fire intensities, a threshold can be determined based on the observed fire effects within each category. This threshold can be calibrated with heat sensitive measuring devices, starting with low intensity burns, and working up to higher intensities if warranted.
8. Develop a set of recommendations that can be tested in prescribed burning situations for cost-effective ways to protect cultural resources, such as removing fuels, establishing fire line standards, or the application of fire retardants.
9. Develop a set of draft guidelines to help land managers ensure the protection of cultural resources in prescribed fire situations.
10. Prepare a final report that includes documentation and discussion of the results of the field experiments.

Proposed Research Questions, Phase II

In order to provide systematic, objective techniques to evaluate fire effects on archaeological materials, the following research questions and research approaches are proposed. The suggested research approaches and test implications are applicable to all USFS fuel model experiments that are recommended

for Phase II. These are not prioritized, and are presented in no particular order. Variables such as temperature, moisture and wind speed are inherent in formulating the prescriptions under which controlled fires are implemented. This information is also critical to the archaeological data set, and separate records will be kept of these variables with respect to cultural resources. To have comparable information between Phase I and Phase II, indigenous materials (for example, Jemez Black-on-white pottery, Polvadera obsidian) will be used when possible. Data from these experiments will be used to develop a synergetic model of fire behavior and cultural resources.

The main objective of this study is to determine whether fire effects alter the interpretive potential of the site and prevent recovering information important to prehistory. The results of the Phase I artifact analysis suggest that there were substantial modifications to artifacts that were probably caused by fire. The following research models are designed to address the question of whether the research potential of a site is compromised through exposure to intentional or unintentional burning.

1. **Architectural Elements**

   Hypothesis.—The tuff construction elements of Jemez-style fieldhouses are blackened, spalled, cracked, and oxidized after being burned in forest fires. The severity of thermal alteration to structural elements of fieldhouses covaries in response to exposure to fire. Disintegration (reduction) of structural elements, exacerbated by fire effects, may contribute to possible misidentification of the structure.

   Research framework.—The effect of fires on architectural components was analyzed during Phase I. It was determined that spalling conforms to the expected pattern, i.e., less spalling on lightly burned sites and more on heavily burned sites. Damage to structural elements, however, may not be the result of the Henry Fire alone; it may be a consequence of the many fires that have occurred over time. Other fire effects such as disintegration, oxidation, and explosion (cracking) of the structural elements were observed on the burned sites. It is not known at what temperature these fire alterations take place or what factors (such as fuel loading across the sites) contribute to these effects. Disintegration of tuff was noted on all types of burned sites as well as the unburned site. Two questions arise: (1) Is rock spiraea (lichen) the main reason for the disintegration of the rock? and (2) To what extent do fire and weathering contribute to the rate of disintegration?

   Research approach.—To test these hypotheses, it is proposed that the architectural questions be tested through the construction of an experimental structure that would be burned under controlled conditions. This structure would be built using multiple construction materials to determine the effects of different fire intensities on a variety of plastic and nonplastic materials such as mortar and building elements. A comparison could be made concerning the fire effects on structural materials of sites that have different fuel loadings placed across the elements. There is some suggestion that selective burning occurs between dry-laid walls and plaster-laid walls. The proposed experimental structure may include a combination of standing walls, plastered, mortared, and dry-laid masonry-welded walls (to replicate Jemez architecture); a jacal wall (San Juan Basin fieldhouse style primarily, but also occurs in the Jemez Province), and rubble. Nonplastic material types used for the architectural elements will be primarily tuff, but also will include sandstone, mudstone, and granite (other rocks local to the area that have been used in prehistoric structures). The plastic medium would be mortar used between the construction elements and as plaster. It may be possible to use rocks with and without lichen to see which elements exhibit disintegration and to what extent it is measurable.

   Test implications.—It was not known whether fire effects on structural elements were the result of the Henry Fire alone or the consequence of the many fires that have occurred over time. The results of this experiment will demonstrate the effects of fires of different intensities and fuel loading on the building elements of structural sites, and the effect of a single burn under controlled conditions on a recently constructed site. A comparative framework will be developed in which the degree of single or multiple fires on tuff structures is known, and a predictive model can be developed to aid in the management of fire behavior and cultural resources. The effects of weathering (a long-term, natural process) is beyond the scope of these experimental situations.

2. Artifacts and Features within Architectural Components

Hypothesis.—The integrity of features and de facto refuse within collapsed structures are preserved. Overburden provides a buffer against fire.

Research framework.—Few data were available from the limited test excavations of structures during Phase I. No features were recovered. Artifacts located within structural components and in the vicinity of fallen logs, however, were substantially thermally altered. This suggested that artifacts are not consistently protected from fire by rubble. Conventional wisdom contends that the "fire passes right over the top" with no effect. Phase I data shows that if residence time is increased through the presence of a burning log or other materials, both the structural and artifactual components of the site experience fire effects. It would be of importance to document the factors that influence the conditions under which cultural resources at small structural sites are affected by fire.

Research approach.—Using the experimental structure described in experiment No. 1, simulate the interior of a fieldhouse. If constructing an entire structure is not feasible, the juncture of two walls (a corner) with appropriate spatial relationships between interior features may provide analogous data. The floor would be partly "prepared" (to monitor the effects of burning on prepared floors), unprepared but foot-compacted (as in Jemez structures), and with corner hearth. The effects on artifacts could also be monitored at this locus. Artifacts could be placed on the floor to monitor fire effects on de facto refuse, and may include perishable items, such as corn cobs, to procure botanical information. The "roof" of this structure would consist of dry logs that have been stockpiled, a layer of artifacts underneath and a hearth. This would simulate the effects of burning roof fall on artifacts and features. The hearth could be sampled by archaeomagnetism and wooden elements would be sampled to see if their dendrochronological potential was destroyed through fire (see below). All experimental artifacts would be marked for identification prior to burning. Duration and intensity of burning would be monitored. Other variables such as moisture content of fuel load, ambient temperature, and wind should also be monitored.

Test implications.—Results of this simulation will provide information on the effects of a single fire episode on features and artifact assemblages at small structural sites. Since it was not known during Phase I whether fire effects recorded on the analyzed artifacts were the result of a single or multiple fires, this experiment will contribute to building a comparative framework.

3. Effects on Ceramic and Lithic Artifacts

Hypothesis.—Lithic and ground-stone artifacts are less susceptible to fire effects than ceramic artifacts. Many lithic artifacts have been deliberately heat-treated during time of manufacture to facilitate stone tool manufacture and to increase the robusticity of the lithic material.

Research framework.—Differential effects on artifact classes were noted during the analysis. This analysis has shown that sherds are more apt to exhibit fire damage than lithic or ground-stone artifacts. This is probably due to the inherent properties of the ceramics themselves: They are more porous and less fire-resistant than lithic artifacts. Sooting is the dominant fire effect on all artifacts, but oxidation, spalling, vitrification, and adhesions also contribute to the alteration of the items. It was not possible to determine whether lithic artifacts had been deliberately heat-treated during manufacture, or by forest fires. It was also not determined what effects were produced by the Henry Fire, and what effects were cumulative.

Research approach.—To test this hypothesis, at loci in the vicinity of existing or experimental sites, mark and place a series of recently manufactured and analyzed ceramic, lithic, and ground-stone artifacts (of local materials) under a variety of burn conditions. Seven principal burn conditions have been defined. These include: (1) on top of duff, (2) in duff, (3) below duff, (4) under a log, (5) in a structure, (6) below surface at 5 cm, and (7) below surface at 10 cm.

After having performed a thorough constituent analysis and retained a portion of the artifact for post facto comparison, distribute a series of unprovenienced prehistoric artifacts from donated collections in the same manner as above. All artifacts within specific contexts should be adjoining, so that they receive analogous degrees of fire damage. These artifacts would be marked for recovery after the fire, and then reanalyzed to provide comparative data.

Temperature, moisture, and other pertinent variables would be monitored.

Test implications.—The results of this experiment would provide information on the effects of fire on newly manufactured artifacts. Inferences could be made concerning degree of effect of one or multiple burns (cumulative or single episode) on ceramic artifacts. It may be possible to evaluate whether a single burn is sufficient to produce spalling, crackling, and oxidation on ceramic artifacts. With lithics, on the other hand, are one or more burning episodes required to produce the appearance of heat-treatment on lithic artifacts? Submitting newly manufactured artifacts to an *auto da fé* ("trial by fire," Kelly and Mayberry 1974) will provide a dimension lacking from Phase I and other fire studies: a knowledge of the appearance of the artifacts prior to exposure to multiple burning through time.

4. **Adhesions on Artifacts**

Hypothesis.—Adhesions are organic deposits produced by fire that attach to artifacts and make analysis and preservation problematic.

Research framework.—Adhesions were noted on artifacts, particularly from sites in the heavily burned categories. The origin of these adhesions was unknown, but is was suggested that they may be pine needle residue, pine sap, or pitch mixed with soot. It is probable that ceramic artifacts are unlikely to benefit by long-term contact with this unknown substance, although more research needs to be done.

Research approach.—Bury a sample of ceramic and lithic artifacts in duff, or under fresh ponderosa branches. Perform the experiment under different fuel loading conditions and monitor degree of fire effects, specifically adhesions. Also, perform a chemical analysis of adhesive materials to determine their composition.

Test implications.—It may be possible to determine at what fire intensity, or under what conditions of fuel loading, adhesions occur on artifacts. Once the identity of the substance is known, and whether it is potentially harmful to the artifact, the effect may be prevented or controlled.

5. **Sooting on Artifacts**

Hypothesis.—Sooting was attributed to the Henry Fire if the soot was loosely adhering to the surface of the item and could be removed with a minimum of effort, such as brushing. This may be a temporary fire effect that has no permanent adverse qualities. Heavy sooting was defined as carbonized particles that would not easily rub off and left a stain on the artifact. It was assumed that heavy sooting, and possible staining of the artifact, was the result of repeated sooting episodes from numerous burns, or a combination of past and recent sooting.

Research framework.—During Phase I the artifacts were analyzed 1 year after the Henry Fire. A nonrigorous definition of sooting directly resulting from the Henry Fire was used during the analysis. It was assumed that substantial amounts of sooting have disappeared due to weathering and other processes, however, some artifacts appeared permanently stained, and their diagnostic potential may have been compromised. It was not determined whether the staining was a cumulative effect of soot from periodic fires over time and thus constitutes "damage." It seems unlikely, however, that the slip of a ceramic artifact will be stained after a single sooting episode.

Research approach.—In a similar experiment to the one outlined above in which adhesions were examined, a series of experimental sherds, lithic artifacts, and recently manufactured obsidian debitage (by-product of lithic artifact manufacture) would be burned under varying conditions of fuel loading. Length of burn, fire intensity, and other variables should be recorded during the experiment. The types of sooting deposited on the artifacts would be analyzed to determine what, if any, integrity has been compromised, if they are stained, or to determine if there are any impediments to artifact analysis. Also of interest is whether the type of sooting from one fire matches the definition used to classify sooting from the Henry Fire. Difficulties in analysis could take the form of obstacles to recovering standard typological/functional data, or surface attributes of ceramics obscured by sooting, or visual impairment of the diagnostic attributes due to sooting during edge-damage analysis on lithic artifacts.

Test implications.—Information about the permanence of sooting and staining and their effect on diagnostic or functional/typological capabilities of artifacts will be provided by this experiment. These data will be used towards developing an objective and rigorous definition of "damage" vs. "fire effects."

6. **Combined Effects of Sooting and Adhesions on Lithic Artifacts Pertaining to Use Wear**
   Hypothesis.—Both adhesions and heavy sooting have the potential for limiting use-wear analysis. Although an untested assumption, it appears plausible that edge damage, because of its typically subtle occurrence (usually monitored microscopically) may be the variable most likely to be overlooked or misidentified under conditions of heavy sooting or adhesions. Use-wear on lithic artifacts provides important information on activities that may have occurred at the site.
   Research framework.—No utilized or retouched edges were noted during the lithic analysis; however, the potential for obscured edge-wear, particularly as a result of sooting or adhesions, was identified.
   Research approach.—The hypothesis can be tested by placing recently created lithic artifacts with consistent edge wear on sites that will be subjected to a variety of burn conditions. Edge-wear analysis will be performed prior to placing the artifacts on the site. After recovery, it will be determined microscopically to what extent edge-wear is affected by the presence of adhesions or sooting (or both).
   Test implications.—It may be possible to determine at what fire intensity, or under what conditions of fuel loading, edge-wear damage on lithic artifacts is hidden by either sooting, adhesions, or a combination of both of these attributes. Also important to this study is to what extent the interpretive potential of that particular artifact has been affected.
7. **Archaeomagnetic and Tree-Ring Dating**
   Hypothesis.—Exposure to fire compromises the archaeomagnetic capabilities of burned hearths, and destroys tree-ring samples.
   Research framework.—Although no features were exposed during Phase I to evaluate effects on the archaeomagnetic properties of hearths, this question still remains unresolved. It was not determined to what extent post-occupational fires compromise the dating potential of prehistoric hearths. Obsidian-dating potential is considered as a separate question below. The effect of fire on tree-ring samples is self-evident. However, it is possible that if tree-ring materials were buried under rubble, the rubble would serve to protect the wood from fire. Of interest is the threshold and survival rate of dendrochronological samples buried beneath rubble, and how much or how little overburden is required for tree-ring samples to burn.
   Research approach.—To evaluate archaeomagnetic data, create an experimental hearth situation. This is explained in experiment Nos. 1 and 2 (above). Daniel Wolfman (pers. comm. 1992) suggests that there are many variables that are already known about archaeomagnetic sampling. An important variable is the threshold above which the magnetic field is affected—around 500° F and burned for at least 12 hours. This has implications for USFS controlled burns that rarely exceed 400° F (see Thresholds, below). Wolfman argues that no useful information could be provided by subjecting a hearth to a fast-moving prescribed burn since the actual conditions under which a prehistoric hearth is affected by fire are not replicated (the prescribed burn is not hot enough to have any effect, and usually prehistoric hearths in architectural contexts are not exposed on the surface). The most productive line of inquiry may be to evaluate hearth features that have been subjected to burning as the result of roof fall, or a log burning in the vicinity. Under the conditions described in Experiment No. 2, a simulated interior hearth of clay would be located underneath burning roof in the experimental structure. The structure would be burned under controlled conditions. Providing the feature satisfies the sampling criteria (deeply baked/oxidized), a standard archaeomagnetic sample would be recovered and measured to determine if the hematite and magnetite particles in the clay have conformed to the ambient magnetic field. To determine the effect of fire on potential tree-ring samples, replicates of vigas will be buried under rubble, and the duration and intensity of fire during a prescribed burning episode will be monitored. Later, the amount of effect on each tree-ring sample in relation to the rubble overburden will be measured and evaluated.
   Test implications.—For the archaeomagnetic experiment, if there is significant variation from the ambient magnetic field, it can be assumed that the chronometric potential of this sample has not been affected by prescribed burning. Tree-ring samples whose outside rings are no longer measurable, or whose pith has been burned, would not be suitable for dendrochronological samples.

8. Obsidian Hydration

Hypothesis.—Although some researchers discourage the use of obsidian hydration for absolute dating (Origer, pers. comm. 1992.), rind measurements can provide a relative chronological framework.

Research framework.—The obsidian hydration analysis performed during Phase I shows that the dating potential of obsidian artifacts is compromised through exposure to fire. At this time, however, there is no basis for comparison between burned and unburned obsidian artifacts, i.e., the obsidian artifacts that were measured in the obsidian hydration analysis may have been burned in past fires.

Research approach.—Origer (above) argues for replication and controlled experimentation with a large sample of artifacts during the obsidian experiments. He suggests that rind measurements be monitored before and after prescribed burning to see if any modification occurs. Origer (pers. comm. 1992.) has expressed a preference for obsidian artifacts over obsidian raw materials for chronometric purposes. He argues that it is unknown how long the cortex of an obsidian nodule has been exposed to hydration processes at the source, but an obsidian artifact falls within a probable temporal range. He also suggests that it may be efficient to reuse the current sample, since it contains hydration bands that have already been measured. The sample would be augmented with experimental debitage and donated obsidian artifacts from collections. Temperature, duration of burning, moisture, and depth should be carefully monitored.

Test Implications.—The use if obsidian hydration as a temporally diagnostic method can be evaluated with the results of this experiment, and the precise degree of effect on rind measurement can be determined. This information can be added to the already growing body of data on the use of obsidian hydration in archaeological research.

9. Material Sources

Hypothesis.—Determining the origin of artifact raw materials is accomplished through trace element analysis. Exposure to fire might reduce, alter, or eradicate the potential for determining those sources with X-ray Fluorescence methods.

Research framework.—No X-ray Fluorescence (XRF) work was done during Phase I; however, the method is widely used throughout the field of archaeology and experimental data can make a significant contribution to XRF research and source materials.

Research approach.—Create experimental sets of debitage from known obsidian sources (Polvadera, Cerro en Medio, Obsidian Ridge, Rabbit Mountain). Retain a control sample from each source category. Do the same for a set of ceramic artifacts with known XRF signatures. Subject the experimental sets to episodes of controlled burning, while monitoring length of experiment, temperature, fire intensity, and other pertinent variables. At the conclusion of the prescribed burn, perform XRF analysis to obtain signatures from the trace elements of each item and compare with original (preburn) signatures from the control samples.

Test implications.—Determining the source of cultural or natural materials through XRF can provide important information on production centers, trade, population movement, and distribution. The extent to which fire influences the XRF potential of Jemez sources is not known, and the data derived from these experiments could be useful in future studies.

10. Discriminating between Past and Present Burning

Hypothesis.—Examination of fire-scarred coniferous trees from the Santa Fe National Forest suggests that the average interval between naturally caused wildfires was 5 to 7 years (see Buchanan et al. in this report). Thus, artifacts in the Jemez Mountains may have been exposed to up to 100 fires in the past. The scarred tree rings indicate that the magnitude of one particular fire is indistinguishable from another (fig. 3).

Research framework.—In several instances during the Phase I artifact analysis, the analysts were unable to distinguish among fire effects from natural causes through time, prehistoric use, and the Henry Fire.

Research approach.—Manufacture 12 pots with similar surface treatments and petrographic properties to prehistoric pots (facsimiles), break them into large sherds, and mark them for identification for retrieval prior to the prescribed burn. Place them in the seven proveniences described above. Retain a control sherd for later comparisons. Collect and reconstruct the pots after burning to determine warping or other

modifications due to fire, and compare with attributes from prehistoric sherds. Other variables that can be monitored include sooting, spalling, oxidation, pigment alteration, vitrification, and adhesions. Oxidation versus reduction effects on ceramic artifacts (oxidation/reduction environments) may also be examined. Eric Blinman (pers. comm. 1992) has proposed that ceramic tiles with selected properties be manufactured to monitor the effect of fires on specific raw materials; for example, a tile with temper similar to Jemez Black-on-white, or a tile with glaze or organic paint surface treatment. These tiles would also have temperature-sensitive lacquer stripes painted on their surface (see below).

Test implications.—If the experimental pots cannot be reassembled due to warping or other factors, then it may be possible to infer that a limited amount of exposure to fire can produce measurable alterations to pottery. This, in turn, provides the comparative data (the single episode) needed for discriminating between artifacts that have been burned numerous times, and those that have been burned during a specific episode. Data from this experiment will also contribute to developing objective, rigorous criteria for "damage," and to building a model of fire behavior and cultural resources.

11. Thresholds

Hypothesis.—Prescribed burning is low-impact, and burns below the temperature threshold at which significant artifact damage occurs.

Research framework.—Phase I research suggests that thermal alteration occurs to artifacts under all fire intensities, but that fuel loading is the critical variable in the severity of damage. These data also suggest that there are differential effects on discrete artifact classes. Ceramic artifacts appear to have a lower tolerance (threshold) than either lithic or ground-stone artifacts. It was not possible to determine under what conditions artifacts sustained fire effects, or the threshold above which measurable fire effects can be discerned.

Research approach.—Thresholds could be monitored by recording fire-line intensities (in BTU/ft/sec.) and temperatures (degrees C/degrees F). Specific temperatures could be obtained by the use of temperature-sensitive devices (thermocouples, temperature indicating lacquers or crayons, thermometers) placed at strategic locations during controlled burning. These locations could include the center of the structure, outside of the structure, at experimental proveniences, and at varying depths below surface. Temperature-indicating lacquer appears to be one of the more flexible and cost-effective methods to monitor maximum temperatures. Past studies (Pidanick 1982) have shown that high and moderate intensity burns in chaparral sites achieve temperatures of 430° C (over 800° F) on the surface. Seven tiles could be prepared, each containing an array of temperature-indicating lacquer strips, ranging from 200° F to 1200° F, and a maximum temperature range for each location could be obtained. Artifact data could be collected through exposure to varying types of fuel loads and intensities, which could then be compared to temperature data to obtain thresholds for different artifact classes and other cultural resources. Duration and post-fire effects would be monitored. Other conditions to be recorded include wind speed, ambient temperature, and moisture, all of which affect the temperatures at which objects and areas burn.

Test implications.—Since USFS prescribed burning occurs under conditions of all fuel loading, a threshold can be determined based on the observed fire effects within each artifact category. These data can contribute substantially to the management of future prescribed burns while minimizing damage to artifacts. Data on temperatures and fire-line intensities can be combined and used to develop a polythetic set (Dunnell 1971) of variables used to measure degrees of effect under different conditions, and to base projections on selected variables, in order to develop a predictive model of fire behavior and cultural resources. For example, with a known set of variables (temperature, site type, artifact assemblage) a predictable amount of fire damage might be expected, and a synergetic model can be applied to anticipated situations. This will be of use to archaeologists and USFS organizations in planning cultural resource management strategies. Much more research needs to be done, however, before these criteria can be developed.

Summary of Proposed Research Design for Phase II

In summary, the OAS proposes to perform a series of experiments designed to replicate the condi-

tion of archaeological resources prior to their exposure to fire. Presumably, this will provide the comparative framework lacking during Phase I of the study.

Phase II research will include:

1. The construction of a composite facsimile site. This site will contain common architectural elements found on Jemez sites and preselected proveniences containing an array of simulated prehistoric artifacts created to prehistoric specifications. Temperature-sensitive tiles will be included in each provenience.
2. A sample of prehistoric sites within a proposed prescribed burn area will be "salted" in the manner described above. A sample of existing prehistoric artifacts will be monitored for prefire attributes.
3. Experimental sites and prehistoric sites will be burned under prescribed conditions of fuel loading and fire intensities.
4. Replicated and actual artifacts will be reanalyzed to monitor the degree of fire effects.
5. Intrasite assemblage artifact evaluation and comparisons with Phase I results will be compiled. This multilinear approach should provide the dimensions and comparative framework needed to develop a predictive model of fire behavior and cultural resources. The results of this study could be applied by the USFS to comply with existing state and federal cultural resource protection guidelines.

Analysis

Laboratory analysis will be conducted by the staff of the Office of Archaeological Studies and qualified professional consultants. Anticipated information from the analysis of different artifact classes will focus on the effects of fire on archaeological materials. Experiments and proposed lines of inquiry are outlined above.

Human Burials

No human burials will be disturbed during the course of Phase II archaeological work. Should human skeletal remains be encountered, work will cease, and appropriate state, federal, and Native American agencies will be notified.

Phase II Report

The final testing and analysis report will be published in the Museum of New Mexico, Office of Archaeological Studies, *Archaeology Notes* series. The report will contain all important tests, analyses, and interpretive results. Included will be photographs, site and feature plans, and data summaries. Field notes, maps, analysis records, and photographs will be deposited with the Archeological Records Management Section of the State Historic Preservation Division, currently located at the Laboratory of Anthropology in Santa Fe. The USFS may also choose to publish the results of the Phase II findings.

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In memory of Dan Wolfman.

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